C.4486(2) MANCHESTER

BUREAU OF HYGIENE & TROPICAL DISEASES
LIBRARY
17 OCT 1928

CITY OF MANCHESTER.

Rivers Department.

ANNUAL REPORT

FOR THE

Year ending March 28th, 1928.

Price: Three Shillings and Sixpence.

Printed for the Manchester Corporation by
HENRY BLACKLOCK & CO. LIMITED, MANCHESTER,
and may be purchased either directly or through any Bookseller from
P. S. KING & SON, LIMITED,
Orchard House, Victoria Street, Westminster, London, S.W.

City of Manchester.

RIVERS DEPARTMENT.

Annual Report

FOR THE

YEAR ENDING MARCH 28th, 1928.

Rivers Department,
Town Hall,
Manchester.

MEMBERS OF THE RIVERS COMMITTEE,

1927-1928.

Chairman—Alderman Fred J. West, C.B.E., J.P.

Deputy-Chairman—Councillor Thomas R. Hewlett, J.P.
The Lord Mayor.

Councillor John Elliott, J.P.
,, Isaac Floyd
,, David Gouldman
,, Thomas Harrison
,, Ernest Hope
,, John E. Hutchinson
,, William Johnston, J.P.
,, James C. Kidd

Councillor Herbert Levinstein
,, Henry F. Robinson
,, John Sever
,, Robert W. Shepherd
,, John W. Sutton, J.P.
,, John M. Wharton, J.P.
,, G. Harold White, J.P.
,, John Williams, J.P.

Consulting Chemist—Edward Ardern, D.Sc., F.I.C.

Secretary—George F. Walter, F.C.I.S.

BUREAU OF HYGIENE & TROPICAL DISEASES
LIBRARY
17 OCT 1928

(3259)

CITY OF MANCHESTER.

Rivers Department.

Annual Report for the Year ending March 28th, 1928.

The Rivers Committee submit to the Council the following report on the work of the Rivers Department :—

Introductory.

The duties of the Rivers Committee are defined in the Council's Instructions to Committees, as follows :—

> " To enforce and carry out the provisions of any public or local Act, or any legal remedy with respect to the rivers, brooks, or streams, wholly or partially within the City, and with respect to all other matters connected therewith ;
>
> " That the said Committee be authorised and instructed to carry out and complete the Manchester Main Drainage Scheme, including all works in relation thereto, and for those purposes to exercise the powers of the Corporation under the Public Health Acts ;
>
> " Also to execute the powers and duties of the Council with respect to the Sewage Outfall Works of the Corporation under paragraph 2 (2) of the Fifth Schedule of the Manchester Corporation (General Powers) Act, 1904 (Chorlton-cum-Hardy Sewage Works to be used only for 3 Withington and 2 Levenshulme Wards) ; Part IV. (Sewerage) of the Manchester Corporation Act, 1908 ; Part V. (Sewerage) of the Manchester Corporation Act, 1909 ; Part IV. (Main Drainage Works) (except section 50) of the Manchester Corporation Act, 1911, and under any other local enactment ; also the provisions as to the discharge of certain matters into sewers, contained in section 21 of the Manchester Corporation (General Powers) Act, 1902, and the orders thereunder ; also to carry out and enforce the provision enabling the Corporation to define the boundaries of rivers, brooks, and watercourses contained in section 55 of the Manchester Corporation Act, 1911 ;
>
> " Also to direct and manage the powers, authorities, and duties of the Council under the Rivers Pollution Prevention Acts, 1876 and 1893 ; section 14 of the Local Government Act, 1888 ; and sections 16, 17, and 47 of the Public Health Acts Amendment Act, 1890."

The total length of sewers constructed under the Manchester Corporation Acts, 1908 and 1911, and completed to date, is 24·53 miles, of which 4·5 miles were executed by the Committee's staff without the intervention of a contractor.

The sewers vary in size from 2·25 ft. to 15·25 ft. in diameter. They are constructed with red engineering bricks and shale bricks set in cement mortar. No surface clay bricks have been used.

Owing to the presence of water in the subsoil, considerable lengths of sewer have had to be executed under air pressure. The completed sewers pass beneath the London, Midland, and Scottish, the London and North Eastern, the Manchester, South Junction, and Altrincham, and the Cheshire Lines Committee Railways in seventeen places, and cross the Bridgewater Canal in seven places.

The Rivers Committee control the admission of all trade effluents into the sewers, according to the provisions of the before-mentioned Acts, and a special Inspector has charge of this work.

The main activity of the Committee is, however, connected with the disposal of the City sewage.

With the exception of the sewage from the Withington district, which receives treatment at the Withington Works, Chorlton-cum-Hardy, the whole of the City sewage is dealt with at the main outfall works at Davyhulme.

In addition, the sewage from the Borough of Middleton and from the area governed by the Barton Rural District Council, together with some portions of the sewage from the Audenshaw and Stretford areas, also passes to the Davyhulme Works. A portion of the old Moss Side Works at Urmston is still retained for the treatment of storm-water only, and the Middleton Sewage Works have been reconstructed to provide for the treatment of a certain proportion of the storm-water from this district.

The following statements show in summarised form the details of the Committee's expenditure for the year under review :—

The total charge on the rates in respect of the work of the Committee was £230,466 9s. 7d.

Of this amount, a sum of £58,503 10s. 7d. was required for the upkeep of the Davyhulme, Withington, Moss Side, and Gorton Sewage Works, and for general rivers work, comprising the administration at the Town Hall, the cost of labour and various rivers improvements, contribution to the Mersey and Irwell Joint Committee, etc.

The remainder, amounting to £171,962 19s. 0d., was applied in the payment of interest on loans and repayment of debt on the capital outlay on intercepting sewers throughout the whole of the City, and on the purification plant at the various sewage works.

The details are as follow :—

	£	s.	d.	£	s.	d.
Administration and Upkeep.						
Davyhulme Sewage Works ..	*45,148	16	9			
Withington	6,424	11	11			
Moss Side	67	18	1			
Gorton	359	6	11			
Middleton	1,174	4	9			
Rivers Account	4,920	19	1			
Main Drainage Scheme (1911) ..	407	13	1			
				58,503	10	7
Interest on Loans and Repayment of Debt.						
Manchester	†69,540	4	10			
Withington	7,239	12	7			
Moss Side	51	11	5			
Gorton	805	7	6			
Rivers Account	506	12	1			
Main Drainage Scheme (1911) ..	93,819	10	7			
				171,962	19	0
Total				£230,466	9	7

WILD BIRDS' PROTECTION.

Following complaints received from a local resident regarding the shooting of wild birds on the Withington Sewage Works, and the prosecution by the police of an offender, the Committee decided to take the necessary steps to extend, if practicable, the powers conferred by the Wild Birds' Protection (City of Manchester) Order, 1925, dated the 11th June, 1925, to the Sewage Works of the Rivers Department which are situated outside the City boundary, together with all lands appertaining thereto. The Committee gave the Town Clerk full authority to effect this purpose, and at the date of this Report negotiations were in progress with the Lancashire County Council regarding the Davyhulme and Flixton Estates and the Middleton Sewage Works, and with the Cheshire County Council regarding the Carrington Estate.

---

* This amount represents the net cost to Manchester after deducting contributions from Audenshaw, Stretford, Barton, and Middleton Authorities (see Table IV. footnote).

† Included in this figure is a sum of £31,000 (approximately), the annual charge on the capital outlay on the Manchester Sewers (apart from the Main Drainage Scheme, 1911), amounting to £627,091, and certain payments in respect of the Middleton Sewage Works.

WORK TO RELIEVE UNEMPLOYMENT.

In February, 1928, the Committee were asked to find work to assist in the relief of unemployment in connection with a scheme of co-operation which had been agreed upon between the Corporation and the Board of Guardians. Four small schemes of flood prevention work were approved by the Council, and are in progress as the present Report goes to press. Full details of the work carried out will be presented in the next Report.

COSTING AND STOREKEEPING.

The system of costing throughout the Department has been the subject of serious consideration for some time past, with the result that an entirely new and complete system of cost accountancy has been established, which has been in successful operation throughout the year reported upon.

The system was designed to provide the following benefits, viz. :—

(*a*) The knowledge that the statements of costs obtained are inclusive of all labour, material, and services, each properly charged to the work or process on which it has been expended.

(*b*) The systematic provision of information by which comparisons can be made between the costs

(1) of different processes serving a common purpose ;

(2) of the same process operated at different works ;

(3) of the work of individual vehicles and appliances ; and

(4) of work performed by direct labour or by contract.

Minor alterations in the scheme suggested by experience have been introduced from time to time, and altogether the scheme has been operated with the greatest success and has provided information of the highest value to the technical and managerial staffs.

Summaries of the labour costs and of stores issued have been supplied monthly to the City Treasurer under the following headings for embodiment in his annual Abstract of Accounts, viz. :—

1 Work on rivers and streams.

2 Repair and maintenance of weirs.

3 Surveillance of rivers and streams and manufacturers' trade refuse.

4 Maintenance of Department's river banks.

5 Sewage pumping and screening, detritus removal, and preliminary tank treatment.

6 Sewage and effluent carriers.

7 Filtration of sewage :—
  (*a*) Operation and maintenance of beds.
  (*b*) Renewal of beds.

8 Activated-sludge plants.

9 Sludge disposal.

10 Chemical laboratories.

11 Depot expenses.

12 Land Cultivation.

13 Administration.

14 Main drainage scheme : revenue charges.

Preliminary Costs.

15 Mobile and other mechanical appliances.

16 Road transport :—
  (*a*) Horse-drawn.
  (*b*) Motors.

17 Rail transport.

18 Power.

19 Workshops.

20 Transport of coal supplies to stores.

21 *Non-recurrent items.*

Weekly records of the labour costs have been supplied to the sectional heads of the Department, and monthly summaries are distributed to each member of the Committee.

The institution of this new costing scheme has called for a better organisation of the storekeeping arrangements at the various depots of the Department.

More extended use of mechanical calculators has reduced any increase in cost entailed in the introduction and operation of this new scheme to a minimum ; in fact, once the new system was thoroughly inaugurated, it has been possible to operate with the single addition of a junior assistant to the clerical staff.

In connection with the establishment of the method of cost accounting now in vogue, the Committee are indebted to the City Surveyor for a valuation, for depreciation purposes, of the buildings at the various depots of the Department, and their thanks are also due to the Chief Engineer and Manager of the Electricity Department and his staff for advice on the subject of the metering of electric current required for power allocation.

MAINTENANCE OF RIVERS AND STREAMS.

The work of the river men has been distributed as follows :—

	Days worked
River Medlock.	
Between Pin Mill and North Western Street	25
,, Hoyle Street and Mayfield	22
,, Hanover Mill and Jackson Street	42
,, Westhead's Weir and Charles Street	28
,, Mynshull Mills and Birley's Weir	33
Cornbrook.	
Between Gardner Street and Bennett Street, West Gorton	31
Moston Brook, Gore Brook, Nico Ditch, Ball Brook, Ley Brook, Pike Fold Brook, and Flash Ditch	10
Posting notices *re* refuse in streams	9
Green Lane Depot.	
Repairing waders, tackle, etc.	17
Westhead's Weir.	
Attending sluices during floods	58
Drawing weir and impounding water at week-ends	18
Assisting engineering staff during repairs, and removing accumulations, etc.	25
Birley's Weir.	
Removing obstructions, cleaning chains, etc.	17
Assisting Rivers Inspector during examinations of rivers, sampling sewers and trade effluents	254

OFFENCES AGAINST THE MANCHESTER CORPORATION ACTS, 1869, 1882, ETC.

Twenty-seven cases of infringement of these Acts have been dealt with. The infringements consist principally in the tipping of solid refuse on river banks within reach of floods, the casting of refuse into streams, and the placing of obstructions therein.

In all cases the removal of the offending material has been required, and where resort to legal notice was found necessary, the work was done by the Corporation at the expense of the offenders.

TRADE REFUSE ENTERING SEWERS.

Frequent inspections have been made of the trade wastes entering the Corporation sewers from manufactories, and of the flow in the sewers receiving such effluents, and a large number of samples have been examined by the technical staff of the Department. From time to time complaints have been made to proprietors as to the acidity of their discharges and as to the presence of excessive solids in suspension, etc.

FLOODS.

River Irk.

A disastrous flood in the River Irk followed a cloud burst in its upper watershed on the evening of the 11th July, 1927. The flood reached its maximum height in the City about 2 a.m. on the 12th. Many works on the Manchester banks suffered extensively, and the footbridge at Bowker Bank was swept away. At several bridges, particularly in the Hendham Vale district, the flood heights were increased by the jamming of floating wreckage across the waterway.

The following heights were recorded in the City :—

	ft.	in.
Boothroyden Bridge	6	0
Heaton Mills Bridge	6	7
Heaton Park Bridge	6	2
Victoria Avenue Bridge	7	9
Blackley New Road Bridge	6	3
Bowker Bank Footbridge	7	11
Delaunay's Road Bridge	8	4
Hulton Brow Bridge	9	2
Tetlow Bridge	9	8
Anchor Bleach Works (upper end).	10	8
Smedley Lane Bridge	8	2
Smedley Road Bridge	3	8
Old bridge below Yew Tree Chemical Works, Collyhurst Road	6	6
St. Catherine's Bridge, Collyhurst Road	7	4
Union Bridge	7	1
Scotland Bridge	5	1

Above the City, in the districts of Royton, Chadderton, and Middleton, where the greatest force of the flood was experienced, the damage to public and private property was enormous.

Bridges and culverts were destroyed, roads were torn up, sewers badly damaged, and the aqueduct carrying the Rochdale Canal across the Irk valley was breached, and upwards of a mile in length of the canal emptied itself into the swollen stream, the volume of which was further augmented by the breaking of the banks of a number of reservoirs.

Three persons lost their lives.

The Borough Engineer of Middleton has kindly supplied the following particulars :—

> The greatest effect of the cloud burst appears to have been felt in the district between Tandle Hill and Royton. No rain gaugings in this region are available, but the Strinesdale gauge of the Oldham Corporation, which is just to the north-east of the storm area indicated, registered on the 11th a rainfall of 4·21 inches, most of the fall occurring between 5 p.m. and 8 p.m., and it is not improbable that even this record was exceeded in the upper watershed of the Irk.
>
> The river culverts under the Rochdale Canal and the L. M. S. Railway embankment were partially choked by trees and other floating timber, and the sections of the valley higher up became lakes.
>
> It is considered that, but for the throttled culverts damming back the water and checking its rush on the town, the havoc in Middleton would have been infinitely greater.
>
> The last previous great flood in the Irk occurred in 1872.

River Medlock.

The River Medlock was also heavily flooded on the 11th July, 1927, the flood levels rising to their greatest heights since July, 1895. The following were the levels above the normal :—

	ft.	in.
Clayton Mill Bridge	7	5
Clayton Vale Bridge	5	3
Clayton Culvert (entrance)	7	8
Mill Street Bridge	7	9
Cambrian Street Bridge	9	5
Holt Town Bridge	8	9
Russell Street Bridge	8	8
Palmerston Street Bridge	7	9
Ancoats Bridge	10	8
Fairfield Street Bridge	11	2
Hoyle Street Bridge	11	5
Mayfield Tunnel	11	3
Boardman Street Bridge	10	9
Downing Street Bridge	10	5
Tennant's Tunnel	10	1
Westhead's Weir (below)	12	2
Princess Street Bridge	12	0
Oxford Road Bridge	10	10
Hulme Street Tunnel	10	3
Birley's Weir (on sill)	6	8
City Road Bridge	8	9
Galloway's Tunnel	8	7
Swallow, Knott Mill (on sill).. ..	8	0

River Irwell.

The uncommonly heavy rainfall in January and February, 1928, caused a series of heavy floods in the Irwell, the highest of which was recorded on the 5th February. The heights are given below :—

	ft.	in.
Broughton Bridge	15	2
Sherborne Street Bridge	12	1
Waterloo Bridge	10	11
Victoria Bridge	9	2
Blackfriars Bridge	8	3
Albert Bridge	7	7
Prince's Bridge	6	1
Regent Bridge	5	6

River Mersey.

A number of heavy floods also occurred in the Mersey during January and February. On February 16th, 1928, the flood levels overtopped the embankments at various places, and the following heights above low-water levels were measured :—

	ft.	in.
Cheadle Bridge	12	9
Didsbury Mill	15	0
Northenden Weir (on sill)	8	3
Palatine Road Bridge	18	1
Darley Avenue	16	3
Withington Pump House	18	4
Stretford Overflow Weir	15	6

During the year plans have been submitted to the Rivers Committee for the following, viz. :—

Nico Ditch	Culverting at Old Hall Lane, Fallowfield.
Shaw Brook	Culverting on the Kingsway Estate, Didsbury. Culverting on the Lathom Estate, Withington
Red Lion Brook	Culverting on the Withington Housing Estate.
Ball Brook	Culverting at Kingsway, Didsbury.

Further repairs have been carried out to the paved invert of the River Medlock at Clayton Vale.

THE TREATMENT OF SEWAGE AT THE WITHINGTON WORKS.

Description of Works.

These works came under the control of the Rivers Committee upon the inclusion of the Withington Urban District Council District within the City on November 9th, 1904. They are situate at Chorlton-cum-Hardy, at the extreme western corner of the district, and are bounded by the River Mersey on two sides—south and west—the Chorlton Brook on the north, and an embankment on the east.

These works were originally designed to purify the sewage by treatment on the land. Subsequently a sedimentation tank and double-contact filter plant was installed as follows:—Two detritus tanks (capacity 83,400 gallons), two sedimentation tanks (capacity 781,000 gallons), ten first contact beds (2,900 superficial yards each), ten second contact beds (2,900 superficial yards each), and an area of storm beds of 12,452 superficial yards divided into four plots measuring respectively 2,882, 3,533, 3,751, and 2,286 superficial yards. A conical catch-pit in connection with the high-level sewer was constructed later (*see* report for the year ending March, 1911). In 1914 two Emscher (double-decked) tanks were constructed of sufficient capacity to deal with from 600,000 to 700,000 gallons per day, a general description of which appeared in the report for the year ending March, 1915.

A continuous-flow unit for the treatment of the sewage by the activated-sludge process was brought into operation in October, 1917, and occupies one-third of one of the above-mentioned sedimentation tanks. A complete account of this plant, together with plan, was given in the Annual Report for the year ending March, 1918.

An additional larger Activated Sludge Unit was brought into commission in August, 1923, and occupies one-third of one of the original second contact beds. A complete description of this installation was given in Appendix I. to the report for the year ending March, 1924; a plan of the same appeared in the annual report for the year ending March, 1923.

A general plan showing the arrangement of the present works appeared in the annual report for the year ending March, 1923.

The land is practically level throughout; consequently it was found necessary, in order to carry out the scheme of double-contact beds, to raise the sewage at the outfall works, and, in order to avoid pumping the whole, to arrange the new outfall main sewers to gravitate the sewage of the upper zone of the district and the whole of the Levenshulme sewage, leaving only that from Didsbury and Chorlton-cum-Hardy to be pumped.

With the River Mersey and Chorlton Brook at ordinary level, the effluent is passed into the latter at a point some 300 yards above its junction with the Mersey; but when the river and brook are in flood it is passed by a syphon under the Chorlton Brook into the Ousel Brook at a point near the Stretford Cemetery, and about half a mile below the Sewage Works. In addition to this, there is a storm-water reservoir nine acres in area for impounding storm water from the Chorlton-cum-Hardy district, as well as a portion of the effluent from the works. When the River Mersey is about its normal level this storm-water reservoir is discharged by gravitation into the river; but should the river be in flood, it is then pumped by means of a suction-gas pumping installation.

In connection with the present main drainage scheme, arrangements have been made whereby the sewage from Levenshulme and Mauldeth Road can be diverted either to the Withington Works or into the main City outfall. No diversion of this sewage to the Davyhulme Works was necessary during the year reported upon.

The total population at present connected with the works is 74,400, viz., Withington 50,100 and Levenshulme 24,300.

The average daily flow of sewage (including storm water) for the year under observation amounted to 4,726,000 gallons, or 63 gallons per head of population per day.

With the exception of the suction gas plant referred to above, the whole of the power used on the works is now derived from the Corporation Electrical Supply.

The plant in the engine room comprises four centrifugal pumps for lifting the low-level sewage, air compressor for delivering the sludge through mains on to the land, and air compressors for the operation of the activated sludge installations, all driven from electric motors of from 15 to 60 H.P.

In addition, there are small motors attached to screens placed on high and low level sewers, and for driving chopping machine.

AREA OF LAND.

The total area of land comprising the Withington Sewage Works amounts to 92·5 acres, and is divided up as follows :—

	Acres.
Land occupied by detritus, sedimentation, and activated sludge tanks	2·25
Land occupied by buildings and sludge tank	
Land occupied by lay-byes and storage	
Land occupied by storm-water reservoir	9
Land occupied by bacteria beds	11·75
Land occupied by storm-water filters	2·5
Total area of land occupied	25·5
The area of land not occupied by bacteria beds, storm-water filters, buildings, tanks, etc., but under cultivation	67·0
Grand total	92·5

Of the land not utilised for sewage treatment an area of 21½ acres has again been let for a portion of the year as grazing land, an income of £69 17s. 6d. having been received.

RIVER MERSEY BANKS.

There have again been no serious disturbances during the year of the River Mersey banks bounding these works, and practically no expenditure has been incurred on their maintenance. The repair of the large break which had existed for many years on the Cheshire side of the river (and which had seriously menaced the stability of the banks on the Committee's lands) has removed one danger and brought another. Flood heights have increased since the break was repaired, and signs have been observed of weakening on the Manchester side.

VOLUME OF SEWAGE TREATED.

The volume of sewage actually delivered at these works is estimated at 1,720,483,000 gallons, an average of 4,726,000 gallons per day. The details of the flow, together with the volume in terms of per head of population and rainfall records, are given in the following table :—

Sewage Flows.

Period of 4 weeks ending	Total Flow.	Average Daily Flow.	Average Daily Flow.	Rainfall.
	Gallons.	Gallons.	Gallons per head.	Inches.
1927				
April 27th	129,803,000	4,636,000		2·24
May 25th	111,219,000	3,972,000		1·38
June 22nd............	95,307,000	3,404,000		2·98
July 20th	127,811,000	4,565,000		3·19
August 17th	108,063,000	3,859,000		2·63
September 14th......	115,580,000	4,127,000		3·31
October 12th.........	163,961,000	5,856,000		4·56
November 9th	146,762,000	5,241,000		3·76
December 7th	112,385,000	4,014,000		1·08
1928				
January 4th	118,803,000	4,243,000		2·01
February 1st.........	198,907,000	7,104,000		6·35
February 29th	176,702,000	6,310,000		3·31
March 28th	115,180,000	4,113,000		1·17
Total for 52 weeks...	1,720,483,000	4,726,000	63	37·97
Total for 52 weeks ending Mar. 30th, 1927	1,462,489,000	4,018,000	55	34·60

A measurable rainfall occurred on 211 days, as compared with 213 days during the previous year.

SLUDGE DISPOSAL.

In the following table is given the amount of sludge removed during the year from the various tanks :—

	Tons
Screening, etc.	380
Conical Tank	660
Detritus Tanks, Sedimentation Tanks, and Activated-sludge Tanks	25,145
Emscher Tanks	1,595
Total	27,780

The total amount of sludge produced, viz., 27,780 tons, is equal to 16·1 tons per million gallons.

The sludge from the detritus, sedimentation tanks, and the bulk of the sludge from the activated-sludge tanks has been trenched into the land as usual.

EMSCHER TANKS.

A general description, together with plan, of these tanks was given in the Report for the year ending March, 1915.

The tanks have been in continuous operation throughout the year, and have dealt with 280,272,000 gallons of sewage, an average of 770,000 gallons per day, as compared with a daily flow of 698,000 gallons during the preceding year. In addition, the plant has dealt with approximately 1,400,000 gallons of activated sludge (99·5 per cent. water), which has been passed direct into one of the sludge chambers for digestion.

A total of 1,345 tons of sludge has been discharged from the tanks during the year, and approximately 250 tons of "scum" containing about 80 per cent. of water have been removed from the vent chambers. Of the 1,345 tons of sludge discharged, 945 tons were passed on to the drainage beds provided ; the remainder (400 tons) has been dealt with on adjoining land.

In view of the proposal to deal with a portion of the surplus activated sludge produced at these works by discharge into the digestion chambers of the Emscher tanks, and the fact that the sludge drying-beds originally provided are barely adequate to cope with the normal sludge production of these tanks, during the past year three new drying beds of fine clinker (225 square yards) have been constructed.

Daily records of the gas production in the two digestion chambers, one with, and one without, the addition of activated sludge, have been taken and the composition of the gases produced has been determined from time to time.

FILTRATION OF EFFLUENT FROM SEDIMENTATION AND EMSCHER TANKS.

Of the total flow of 1,720,483,000 gallons of sewage received at the works, 517,380,000 gallons were treated by the activated-sludge process, and the remainder, viz., 1,203,103,000 gallons, was dealt with on the filtration areas.

The storm beds dealt with a total volume of 198,431,000 gallons, which is equal to 218,000 gallons per acre per day. The primary and secondary beds dealt with a total volume of 1,004,672,000 gallons, which means that on the average (including all periods of rest), tank effluent was applied to the primary beds at the rate of 460,000 gallons per acre per day.

The work on the surface of the filter beds in connection with the removal of accumulated sludge and of heavy growths of weeds, etc., has proceeded as usual, the cost of which for the various filtration areas is given in Table II.

TREATMENT OF SEWAGE BY THE ACTIVATED-SLUDGE PROCESS.

Purification plant in operation for the treatment of sewage by the activated-sludge process—diffused aeration system—consists of (i.) a small continuous-flow unit installed in 1917, and described with plan in the Annual Report for the year ending March, 1918, and (ii.) a large-scale continuous-flow unit installed in 1923 and modified in 1926. A description of the large-scale unit as originally installed is given with plan in the Annual Report of 1923 ; the modifications of 1926 are referred to in the Annual Report of last year, page 16.

The air-compressing plant comprises two reciprocating compressors, driven by 27 and 30 H.P. electric motors respectively, each capable of compressing approximately 700 cubic feet of free air per minute, and a modern type compressor (installed in 1924), driven by a 25 H.P. electric motor, capable of compressing 400 cubic feet of free air per minute. One of the larger compressors is used as a stand-by.

The normal working pressure is 4lbs. per square inch.

Each purification unit is provided with meters, etc., for recording the volume of sewage treated and the volume of air used. A meter is also provided for the measurement of the electrical units consumed.

Prior to passing to the aeration tanks the sewage is screened and freed from the coarser suspended solids by passage through detritus tanks having a capacity equivalent to 40 mins. D.W.F.

During the past year a total volume of 517,380,000 gallons of screened and detritus-free sewage has been treated by the two units, which represents approximately 30 per cent. of the total volume of sewage received at the works.

SMALL-SCALE UNIT (RIDGE AND FURROW TYPE).

This unit has been in continuous operation throughout the year and continues to give consistently good results. The average analytical returns, etc., are tabulated below :—

SMALL UNIT.

Results in grains per gallon.

	Screened and detritus-free sewage	Effluent
Four hours oxygen absorption	2·55	·48
Three minutes oxygen absorption :—		
Before incubation	·94	·19
After incubation	—	·16
Putrescibility	—	8/251
Free and saline ammonia	2·04	1·96
Albuminoid ammonia	·59	·135
Nitrite (in terms of NH_3)	—	trace
Nitrate (in terms of NH_3)	—	·10
Biochemical oxygen demand (†Royal Commission Test)	—	·94
Suspended solids	9·5	·57

Total volume of sewage treated	133,395,000 gallons
Volume of sewage treated per day (average)	366,000 ,,
Air consumption :—Free air per gallon of sewage treated	1·09 cubic feet
Average detention period :—	
Aeration tank (capacity, 60,000 gallons)	4·0 hours
Settlement tank (capacity, 27,000 gallons)	1·8 ,,

---

† Standard recommended not more than 1·40.

Throughout the year no difficulty has arisen with respect to sludge control.

LARGE-SCALE UNIT.

In order to complete the investigation with regard to the "Relative Efficiencies of Various Types of Aeration Chambers," described in detail in last year's Report (Appendix I.), for a period of two months (60 days), one aeration chamber only (of two), of this unit was in commission. On completion of the investigations on June 24th, both aeration chambers were brought into use and normal working conditions, with the exception of sludge re-aeration which has been discontinued throughout the year, were resumed.

The average analytical returns and other data with respect to this unit are tabulated below :—

Results in grains per gallon.

	Screened and detritus-free sewage	Effluent
Four hours oxygen absorption	2·55	·51
Three minutes oxygen absorption :—		
Before incubation	·94	·21
After incubation	—	·19
Putrescibility	—	20/248
Free and saline ammonia	2·04	2·01
Albuminoid ammonia	·59	·145
Nitrite (in terms of NH_3)	—	trace
Nitrate (in terms of NH_3)	—	·10
Biochemical oxygen demand (†Royal Commission Test)	—	·96
Suspended solids	9·5	·64

Total volume of sewage treated	383,985,000 gallons
Volume of sewage treated per day (average)	1,055,000 ,,
Air consumption :—Free air per gallon of sewage treated	1·01 cubic feet
Average detention period :—	
Aeration tank	5·3 hours
Settlement tank	2·0 ,,

Standard recommended not more than 1·40 grains per gallon.

Power Costs.

As both activated-sludge units have been in full commission since 24th June, 1927, some reliable data with respect to the all-in power costs, in connection with the treatment of sewage by the activated-sludge process, are available.

Period—24th June, 1927, to 28th March, 1928.

Total volume of sewage treated (two units) ..	439,770,000 gallons
Average pressure air mains	4·5lbs. per sq. in.
Electrical units consumed—total	187,100 units
Cost per unit	0·7d.
Cost per million sewage treated	£1 4s. 10d.

MOSS SIDE SEWAGE WORKS.

The storm-water overflow at these works came into operation on 94 occasions during the year ; the average depth measured over a 6ft. sill was 10 inches.

The total amount of semi-dried sludge removed from the storm-water lagoons was 167 cubic yards.

The maintenance costs are given in Table III.

GORTON SEWAGE WORKS.

These works are now completely out of commission, and it is not intended that any portion of them shall be brought into operation again for the treatment of sewage or storm-water. The Department is prepared to consider an offer for the disposal of the property.

An area of 422 square yards has been given up to the street for the widening of Mount Road, Gorton, and the high brick boundary wall abutting on Mount Road is being set back.

The charges in connection with these works are given in Table III.

MIDDLETON SEWAGE WORKS.

During the year the re-conditioning of the Middleton Sewage Works for use as a storm-water station has been carried out. The Boothroyden sewer, which conveys the Middleton sewage to the Manchester sewers, is at present only capable of taking four times the dry weather flow from the Middleton area. Therefore, the old filter beds have been emptied of medium and transformed into storm-water tanks to treat the excess flow between four and six times the dry weather flow. A storm-water overflow chamber has also been constructed on the connecting sewer. Further tank area will have to be provided later as the dry weather flow from Middleton increases.

The expenditure incurred during the year is itemised in Table III.

ROYTON SEWAGE.

The drainage of three small properties situated in the district of Royton has been accepted into the Manchester system under special agreement with the Royton Urban District Council. This sewage will be received by way of the sewers of the Chadderton and Middleton Councils.

THE TREAMENT OF SEWAGE AT DAVYHULME.

Description of Works.

The original works, which came into operation early in 1894, were designed for the treatment of the sewage by chemical precipitation.

The new works for bacterial treatment of the sewage were completed in 1904 so far as to permit at that date of the whole of the dry-weather flow being dealt with in tanks and primary contact beds.

A general plan showing the arrangement of the existing works appeared in the Annual Report for the year ending March, 1923.

The sewage as it reaches the works passes through a system of screens and catch-pits, designed to intercept coarser floating matter and heavy detritus. The flow is either passed through open septic tanks on to primary bacteria beds, or, after simple sedimentation, on to the storm beds.

The sludge which settles or accumulates in the course of time in the septic tanks flows by gravity, or is pushed by manual labour, into the channels leading to two ejectors, from which the majority of the sludge is forced under air pressure into three storage tanks near the banks of the Ship Canal below Barton Locks. From these tanks it flows by gravity into the sludge steamer, and is deposited at sea beyond the Mersey Bar. A small proportion of the sludge is dealt with in presses, and the resultant pressed cake either before or after drying is disposed of as a fertiliser.

A complete description of the scheme originally sanctioned by the Local Government Board is given in the report, entitled "Treatment of Manchester Sewage," issued in July, 1902, where the details of construction of the primary contact beds and storm-water beds may be found.

Subsequently permission was granted by the Board to construct the secondary beds at Bent Lanes, adjacent to the original works, instead of at Carrington and Flixton.

A general description of the construction of the secondary beds is given in the Annual Report for the year ending March, 1909.

Extensions of Works.

As stated in previous reports a scheme for the extension of the existing purification plant was approved by the Ministry of Health in September, 1925, which provides, *inter alia*, for the construction of additional detritus tanks and new screening chamber, activated-sludge units to deal with a minimum of one-half the dry weather flow of sewage, together with the proportion of storm-water requiring full treatment, and the provision of a sludge main from the Davyhulme Works to land owned by the Corporation at Flixton and Carrington.

The sludge main is now in commission and the detritus tanks and screening chamber nearing completion. Detailed drawings of the activated-sludge units, etc., are in course of preparation. A full description of these extensions is reserved for a future report, when the new plant is ready to be brought into commission.

The total cost involved is estimated to be about £500,000.

Power Supply.

The steam plant was displaced in September, 1923, and since February 2nd, 1924, the works have been supplied with current by the Corporation Electricity Department by direct cable from the Barton Power Station, at a pressure of 6,600 volts to two 250 K.V.A. transformers, where it is stepped down to 440 volts for power and 220 volts for lighting purposes.

Panel switch-boards, complete with main cut-outs and meters, are provided for both high and low tension current.

The motors throughout the works are designed for 3-phase, 50 cycle. A.C. current, and have a total working output of 500 B.H.P.

There are two 60 B.H.P. motors for driving Alley-McLellan air compressors (high pressure) for operating sludge ejectors and sludge presses; two 47 B.H.P. motors driving two 10in. Gwynne " Invincible " pumps, each capable of delivering 2,500 gallons per minute against a 40 foot head, employed for pumping off top water from sedimentation and septic tanks prior to removal of sludge; one 35 B.H.P. motor driving the new activated-sludge compressor and three 30 B.H.P. motors for driving three Reavell air compressors (low pressure) intermittently employed in connection with the Activated Sludge plant; one 30 B.H.P. motor driving a Ruggles-Coles dryer, and one 24 B.H.P. motor also used in connection with sludge drying; one 20 B.H.P. motor used for driving purposes in the fitting shop; two 20 B.H.P. motors for operating sewage screens and elevators; two 10 B.H.P. motors for operating the two clinker washing plants; and five small motors from 1·5 to 10 B.H.P. used for sundry other purposes.

DRAINAGE OF THE PARISH OF DAVYHULME.

Some time ago an agreement was entered into with the Barton Rural District Council to treat the sewage from the Davyhulme Parish at the Davyhulme Works.

The sewage contributed by the population in Crofts Bank Road, Barton Road (part of), Davyhulme Road, and Bent Lanes is discharged at two points—*i.e.*, Point " C " and Point " E." That discharged at Point " C " passes over shallow filter beds, and then into the feed channel to the secondary beds.

The sewage delivered at Point " E " is conveyed by means of a 2ft. diameter brick sewer, on which a storm-water overflow is fixed at the Bent Lanes Brook, and which is intended to limit the volume of sewage passed on the estate of the Corporation. The sewage is delivered into a manhole referred to in the Agreement as Point " E," and from which it gravitates through three 6in. diameter cast-iron pipes to a " recorder chamber," where the flow is measured by means of a " V " notch of the type designed by Messrs. Lea, of Manchester, and has a maximum recording capacity of 10,000 gallons per hour. After passing over the notch the sewage flows on to pneumatic ejectors of 200 gallons capacity, in duplicate, each fixed in cast-iron tubbing.

These ejectors raise the sewage by means of compressed air, supplied from the main engine house at the works, into the feed channel supplying the existing septic tanks.

Area of Land.

The total area of land comprising the Davyhulme Works amounts to 238·5 acres, and is divided up as follows :—

	Acres
Land occupied by storm water, detritus, open septic tanks, and activated-sludge plant	10·1
Land occupied by buildings, sludge tanks, etc., and land occupied in connection therewith..	15·0
Land occupied as wharves, lay-byes, and storage	5·0
Land occupied by first contact bacteria beds..	46·0
Land occupied by second contact bacteria beds	39·0
Land occupied by storm-water filters	26·8
The area of land not occupied by bacteria beds, buildings, tanks, etc., but includes existing roads, railway and embankments, and disused river bed..	96·6
Grand total	238·5

TENANCIES, ETC., OF LANDS.

During the year covered by this Report the Committee's lands at Carrington and Flixton have been supervised from the Town Hall as heretofore, and periodical inspections of crops have been made by the officer of the Agricultural Committee of the Corporation. Materials have been supplied for drainage operations on the Carrington land.

The laying of the sludge main from the Davyhulme Sewage Works to the lands lying in the River Mersey meadows at Flixton was completed in October, 1927, and this main was brought into regular commission in March, 1928. During the year arrangements for the final easement for the passage of the sludge main have been completed, and four claims for compenstiaon in respect of disturbance and surface damage and loss of crops have been met. Operations on the sludge main also caused one or two minor alterations of tenancy owing to land being required by the Department for the receipt of discharges from the scour valves. In addition to these, there have been three major changes of tenancy, in one case the Department taking over the holding of an unsatisfactory tenant and farming the land themselves.

The whole of the Flixton lands in the River Mersey meadows continue to be used by the Department either for crops or for sludge trenching operations. The total area of land let to farmers, etc., at the date of this Report is approximately as follows, viz. :—

	Area a.	r.	p.		Annual Rental £	s.	d.
Townships of Stretford and Davyhulme	11	0	11	..	16	10	4
Township of Carrington ..	89	3	10½	..	108	15	10
Township of Flixton	66	2	2	..	134	0	6
Totals	167	1	23½	..	259	6	8

The laying of the Gas Committee's high-pressure gas main from the new Partington Works has been completed during the year with the exception of that portion which is carried across the River Mersey.

River Mersey Banks.

The year has been an unfortunate one for the banks of the River Mersey on the Carrington as well as the Flixton side of the river. The heavy floods of the autumn were obstructed by the scaffolding of the lattice girder bridge which the Gas Committee were erecting across the river, and the backing up and eddying of the water brought the bank down in several places. The Council approved a special estimate to cover the cost of reinstating and consolidating the eroded banks. Minor repairs would probably have been sufficient to check erosion, but the safety of the Gas Department's bridge and the high-pressure gas main made it necessary for the work of repair to be well done. The total cost was £661 19s. 2d., half of which is payable by the Gas Department.

In October, 1927, the lattice girder bridge collapsed into the river. As a result of the heavy rainfall of January, 1928, and the obstruction caused by the collapsed bridge, further erosions took place, and the Gas Department has agreed to pay the cost of reinstatement provided that the Rivers Department carry out certain piling to protect the concrete piers of the bridge.

VOLUME OF SEWAGE TREATED.

The volume of sewage delivered at the works from March 31st, 1927, to March 28th, 1928 (inclusive), including 30,485,000 gallons from the Parish of Davyhulme, was 18,629,970,000 gallons.

The average daily flow of sewage was 51,181,000 gallons, showing an increase on the previous year of 3,070,000 gallons, or 6·4 per cent.

The average daily flow of sewage per head of population has ranged from a minimum of 55 gallons for the four weeks ending May 25th and December 7th, 1927, to a maximum of 98 gallons for the four weeks ending February 1st, 1928.

MONTHLY RECORDED SEWAGE FLOW AND RAINFALL.

Period of four weeks ending	Sewage		Rainfall				
	Flow	Average Daily Flow	Davy-hulme	Oldham Road	Platt Fields	Heaton Park	Godlee Obser-vatory
	Gallons	Gallons per head	Inches	Inches	Inches	Inches	Inches
1927							
April 27th	1,317,331,000	62	2·29	2·40	2·09	2 59	2·153
May 25th	1,179,045,000	55	1·40	1·52	1·26	1·62	1·271
June 22nd	1,198,620,000	56	3·30	2·87	2·97	2·63	2·840
July 20th	1,454,893 000	68	3·41	3·91	3·56	4·39	3·439
August 17th	1,307,798.000	61	2·98	3·11	2·30	3·51	2·742
September 14th	1,452,556.000	68	4·22	4·52	3·73	5·85	3·994
October 12th	1,669,021,000	78	5·15	5·16	5·04	5·25	4·781
November 9th	1,562,353,000	73	4·24	4·53	3·86	5·59	4·161
December 7th	1,170,251,000	55	1·26	1·11	·95	1·14	1·004
1928							
January 4th	1,215,846,000	57	2·11	2·07	1·90	2·44	2·035
February 1st	2,089,453,000	98	7·00	7·80	6·64	7·75	6·865
February 29th	1,760,881,000	82	3·92	3·75	3·79	4·71	3·799
March 28th	1,251,922,000	59	1·52	1·56	1·35	1·72	1·467
Totals for 52 weeks	18.629,970,000	65	42·80	44·31	39·44	49·19	40·551
Totals for 52 weeks ending March 30th, 1927	17,512,465,000	63	36·42	36·90	35·65	42·15	34·825

The number of days on which a measurable fall of rain (·01 inch or over) occurred during the 52 weeks was as follows :—

Davyhulme	200 days.
Oldham Road	203 ,,
Platt Fields	201 ,,
Heaton Park	203 ,,
Godlee Observatory ..	205 ,,

TOTAL VOLUME OF SEWAGE FILTERED.

The total volume of sewage dealt with by the various filter beds (primary contact and storm-water filters) and by the activated-sludge process during the year amounted to 8,658,087,000 gallons, or 46 per cent. of the total flow of sewage.

Of the total quantity thus dealt with, 5,758,259,000 gallons were treated on the secondary filter beds. This volume is equal to 67 per cent. of the primary effluent, or 31 per cent. of the total sewage flow.

Practically the whole of the unfiltered sewage received treatment in sedimentation tanks prior to its discharge to the canal.

Particulars of the quantities and composition of the raw sewage and unfiltered tank effluent are given in Tables IV. and VII., together with comparative figures for the year ending March 30th, 1927.

The rate of the conversion of pail-closets during the past twenty-four years is given in the following table :—

Period	Number of Pail-closets converted
1905–1909	45,567
1910–1914	34,359
1915–1919	1,071
1920–1924	92
1925–1928	29

There are now comparatively few houses not served by the water-carriage system.

The amount of suspended matter in the sewage and various effluents together with the comparative figures for two preceding years, is given in Table XV.

SLUDGE DISPOSAL.

The total sludge production during the year was 197,792 tons, which is equal to 10·62 tons per million gallons sewage treated. Of this amount 170,319 tons were sent out to sea, 535 tons dealt with by the sludge presses and subsequently dried and sold as a fertiliser, 6,723 tons were pumped to Flixton and deposited on land, and 20,197 tons of water or thin sludge were decanted from the sludge storage tanks (prior to loading the steamer), and discharged on to drainage beds.

During the year the sludge steamer "Joseph Thompson" made 170 voyages, an average of 3·27 trips per week. The total mileage covered was 22,100 (statute), an average of 425 miles per week. The total coal consumption was 1,952·6 tons, an average of 11·5 tons per trip.

The new sludge main from the Davyhulme Works to the Committee's land at Flixton (some 2½ miles distant) was available for use during the closing months of the year reported upon. One hundred acres of land are at once available here for the disposal of sludge, and, if required, a further large area of land can be brought into similar use in the near future.

Various methods of land treatment are being investigated, such as, *e.g.*, (A) shallow rectangular trenching as practised at the Withington Works, (B) ploughing (ridge and furrow), and (C) broadcasting on lightly-ploughed land with subsequent ploughing, to determine which method is most applicable to the condition prevailing on the available land area.

The experience gained to the date of publication of this Report indicated that by one or other of these means large volumes of sludge can be successfully and economically dealt with. The relief thus afforded to the sludge steamer (sea disposal) radically alters the position in respect of sludge disposal at the Davyhulme Works, which was in danger of becoming a source of serious anxiety.

It is already evident that once certain preliminary costs, *e.g.*, cost of temporary sludge pump and house, drainage of land, etc., are finished with, the cost of this method of dealing with sludge, will compare very favourably with that of sea disposal.

Owing to the state of the fertiliser market, and following a careful examination of the whole of the circumstances, the production of dried sewage manure has been discontinued for the time being. The plant is being kept *in situ* in the event of a revival of trade, and particularly in view of the possibility of its utilisation for the drying of activated sludge.

Details of the cost of sludge disposal are given in Tables IV. and V.

TREATMENT OF THE SEWAGE IN SEDIMENTATION TANKS.

Sedimentation Tanks.

The six tanks referred to in the report for the year ending March, 1917, have been in operation as sedimentation tanks throughout the 12 months under observation.

The total flow through these tanks (water-holding capacity, 6,750,000 gallons) during the year amounted to 9,971,883,000 gallons, or 27,395,000 gallons per day.

In the following table particulars are given of the amount and character of the sludge removed from the individual tanks :—

Tank No.	Sludge Tons	Per cent. Water
6	24,296	88·2
7	30,266	89·5
8	24,040	89·5
9	13,788	88·3
10	24,478	89·9
11	21,009	89·7

The total quantity of sludge removed from the sedimentation tanks was 137,877 tons, or 13·8 tons per million gallons treated. The amount of sludge removed from these tanks is equal to 72 per cent. of the total tank sludge production.

Storm Beds.

The media of this disused filtration area continues to be gradually utilised in the manner stated in the last Report, *i.e.*, the media is being burnt *in situ* and subsequently removed, washed, and screened. The larger-sized material is employed in the renewal of the primary beds and the finer material sold for making paths, tennis courts, and for other purposes.

TREATMENT OF THE SEWAGE IN OPEN SEPTIC TANKS AND BACTERIA BEDS.

Open Septic Tanks.

There are now 10 tanks in operation as open septic tanks. The length of each tank is 300 feet, and the width and depth of five of the tanks is 100 feet and 6 feet (average) respectively ; the other four tanks are shallower, but of greater width, while No. 12 tank (a portion of which is occupied by the activated-sludge unit) is now only 66 feet wide.

The total holding capacity of the 10 tanks is about 12,000,000 gallons.

The total flow of sewage through the septic tanks during the year amounted to 8,658,087,000 gallons, or 23,786,000 gallons per day.

In the following table are given details of the amount and character of the sludge removed from the various tanks :—

Tank No.	Sludge Tons	Per cent. Water
3	2,822	86·2
4	4,635	90·4
5	10,653	91·6
12	8,649	91·5
13	4,014	90·4
14	5,433	88·3
15	13,602	90·3
16	2,794	89·5

The total sludge removed from the septic tanks was 52,602 tons, an average of 6·3 tons per million gallons.

Half-acre Primary Beds.

This filtration area has dealt with a total volume of tank effluent of 8,521,530,000 gallons at an average rate (over the whole area) of 509,000 gallons per acre per day, or 94 gallons per cubic yard per day, as compared with last year's figure of 547,000 gallons per acre, or 101 gallons per cubic yard per day.

The continued reduction of the volume of tank effluent filtered is consequent on the policy adopted two years ago to work all recently renewed beds on the basis of the rate it is expected they will be called upon to operate at when the present extension scheme is completed. It was hoped by so doing that a manifest improvement would be obtained in the quality of the effluents produced, and during the past year an improvement has certainly been obtained, but not to the extent anticipated.

During the year under observation the washing, rescreening, and replacement of the media of sixteen beds has been completed, and the beds placed again in commission. These beds had been in operation for periods varying from five years nine months to eight years nine months since their previous renewal, and had received from 5,800 to 8,200 fillings of tank effluent meanwhile.

The average analytical returns, showing the results of treatment together with the volumes of tank effluent dealt with, and comparative figures for the previous year, are given in Table VIII.

The operating, maintenance, and renewals cost are summarised in Table IV., together with particulars relating to the volumes of sewage treated on the various sections of the filtration areas.

SECONDARY BEDS.

Experimental Half-acre Bed No. 10a.

This bed has now been in operation 23 years, and continues to receive 18 fillings of primary effluent per week, with suitable recuperative periods. Reference to Table IX. will show that the volume of primary effluent treated was 50,616,000 gallons, an average of 278,000 gallons per acre per day, or 70 gallons per cubic yard per day. The analytical returns recorded in this table show that the usual high quality effluent has been maintained.

No. 1 Secondary Bed.

This bed continues to be operated as a contact bed, receiving usually 12 fillings of primary effluent per week.

The records given in Table X. show the volume of primary effluent treated and the character of the resultant filtrate.

Second Contact Beds (Nos. 2 to 39).

The details of the construction of these beds are given in the Annual Report for the year ending March, 1909. The usual maintenance attention has been given to the surfaces of these beds, the cost of which is given in Table IV. There has been no renewal work on this section of the filtration area during the year reported upon.

The quantities of primary effluent treated and the results of the analyses of the filtrates from the various sections of the secondary beds are given in Tables XI. to XIV., together with the comparative figures for the previous year.

SHIP CANAL WATER.

The results of the incubation test as applied to the canal water taken above the works outfall, together with a record of rainfall and air temperatures, are given in Diagram 1.

This diagram illustrates once again that the principal factor governing the quality of the canal water is the incidence of the rainfall, although, of course, the prevailing aerial temperature is not without some influence.

Consequent on the dry period experienced in April and May, 1927, the canal water became putrefactive (on incubation) earlier in the year than is usual; on the other hand, heavy rainfall in June, and again in August, kept the canal water non-putrefactive practically throughout the summer months, the period when the water is usually in its worst condition.

A wet September and moderate rainfall during the latter half of October maintained this improved condition throughout the autumn, and it was not until the dry period in March, 1928, that the canal water again became putrefactive on incubation.

The results of the complete examination of the canal water above and below the outfall from the Davyhulme Works are recorded in Table XVI., together with results for the preceding eight years. The results of the incubation test only are shown in Diagram 2.

SUMMARY OF RESULTS (DAVYHULME WORKS).

The following summary of the results of operation of the Davyhulme Works is submitted:—

Total sewage flow—
Main outfall .. 18,599,485,000
Davyhulme Parish, Point "E," 30,485,000 } = 18,629,970,000 gallons.

Total sludge removed .. .. .. = 197,792 tons.
= 10·62 tons per million gallons.

Total volume of sewage filtered (primary contact beds and storm beds) .. .. = 8,521,530,000 gallons.
= 45·7 per cent. of the total sewage flow.

Volume of sewage treated by the activated-sludge process .. .. = 136,557,000 gallons.
= 0·7 per cent. of the total sewage flow.

Total volume filtered by secondary beds .. .. = 5,758,259,000 gallons.
= 67·0 per cent. of the primary effluent.
= 31·0 per cent. of the total sewage flow.

Total Revenue Cost (apart from Interest Charges and Repayment of Debt) :—

= £3 3s. 3·9d. per million gallons.

Average Cost per Head of Population—

		s.	d.
For year ending 28th March, 1928	=	1	6·6
For twenty-three years ending 28th March, 1928	=	1	2·7

Results of Treatment (expressed in grains per gallon).

Four hours oxygen absorption			Albuminoid ammonia		
Raw sewage	Average effluent, including unfiltered tank effluent	Percentage purification	Raw sewage	Average effluent, including unfiltered tank effluent	Percentage purification
7·20	3·93	45%	·55	·30	45%

In Table XVII. will be found particulars of the cost of sewage treatment at Davyhulme for the period 1896-1928, including the total outlay on sewage disposal works up to date, annual maintenance, and annual capital charge (payment of interest and repayment of debt), which has been estimated on the basis of 5 per cent. of the outlay to date. The costs are also given in terms of the amount per head of population. The percentage purification effected by the treatment of sewage during the different years is also shown, together with the estimated population connected to the sewers.

RESEARCH WORK.

Demonstration Activated-Sludge Plant.

The adverse conditions with respect to air supply which have existed for practically the whole of the time this plant has been in operation were intensified during the first quarter of the year under review, the total available air supply being limited to 420 cubic feet of free air per minute. With the curtailed capacity of the installation, referred to in the last Annual Report, it was found possible to maintain the plant in satisfactory operation on this air supply, but the average volume of sewage treated was limited to 240,000 gallons per day. Operating at this rate, the mean detention period was seventeen hours, and the air consumption 2·2 cubic feet of free air per gallon of sewage treated. The quality of the effluents obtained may be judged from the average analytical returns for this period, which are as follows :—

Results in grains per gallon.

	Crude sewage	Settled sewage	Effluent
Four hours oxygen absorption.. ..	7·45	5·70	1·21
Free and saline ammonia	2·62	2·73	2·46
Albuminoid ammonia	·61	·445	·13
Oxidised nitrogen (in terms of NH_3)	—	—	·06
Putrescibility	—	—	0/85
Biochemical oxygen demand	—	—	·94
Suspended matter	19·6	3·8	1·8

In July and August, 1927, a new compressor, supplied by Messrs. Activated Sludge Ltd., was installed in the main engine room. The machine is of a new four-cylinder reciprocating type, with cylinders of twelve-inch bore and a six-inch stroke. It is belt-driven at a speed of 260 r.p.m. by a 35 B.H.P. motor running at 960 r.p.m. The compressor is air cooled, and was guaranteed to have an overall efficiency of 61 per cent. at 4·5 lbs./square inch pressure. Official tests over periods of six hours demonstrated an overall efficiency of 71 per cent. at a pressure of 4·5 lbs./square inch and of 67 per cent. at the working pressure of 5·7 lbs./square inch. Advantage was taken of the enforced idleness of the plant during these alterations to renew the diffusers, many of which had been in operation for about six years.

Since the plant was restarted it has been in continuous operation with the exception of about ten days, during which time sludge was removed from the tank which supplies the plant with settled sewage. During the last six months of the year under review the plant has dealt with a total volume of 106,318,000 gallons, at an average rate of 611,000 gallons per working day. At this rate of operation the average detention period was 6·7 hours, and the air consumption was 1·5 cubic feet of free air per gallon of sewage treated. The average analytical returns indicating the performance of the plant during this period are as follows :—

Results in grains per gallon.

	Raw sewage	Settled sewage	Effluent
Four hours oxygen absorption	6·82	6·00	1·58
Free and saline ammonia	1·93	2·01	1·84
Albuminoid ammonia	·525	·42	·14
Oxidised nitrogen (in terms of NH_3)	—	—	·14
Putrescibility	—	—	½/174
Biochemical oxygen demand	—	—	1·63
Suspended matter	16·3	9·9	2·7

These results are of interest by reason of their bearing on operation economics. They show that with an adequate air supply (per super. area of the aeration chambers) the volume of sewage treated may be very considerably increased without necessarily increasing the volume of air employed per gallon of sewage dealt with.

In 1923-4, before the curtailment of the volumetric capacity of the plant, an average flow of 874,000 gallons of sewage was treated per day, which is equivalent to a daily flow of 393 gallons per cubic yard of tank capacity (aeration and reaeration chambers combined), or a detention period of about ten hours. The air consumption was equal to 1·22 cubic feet of free air per gallon of sewage treated.

The reduced tank has dealt with 611,000 gallons per day, or 606 gallons per cubic yard per day, an increase of roughly 50 per cent. per unit capacity, the detention period being reduced by one-third to 6·7 hours, whilst the air consumption has only increased by 23 per cent., *i.e.*, from 1·22 to 1·50 cubic feet of free air per gallon of sewage treated.

Accurate measurement of power requirements show that during the six months referred to above 20·9 H.P. have been absorbed per day, which is equal to 34·3 H.P. per million gallons of sewage dealt with.

This investigation confirms the results previously obtained at the Withington Works in indicating that for any individual sewage there is an optimum air supply, which, in turn, may vary with the design of the installation.

"AEROFILTERS."—PRELIMINARY INVESTIGATION.

In view of the favourable reports noted elsewhere on the use of "aerofilters," an investigation has been carried out in which it was sought to compare the merits of this type of filter with those of the ordinary percolating filter. Two similar filters were constructed, each consisting of four feet of stoneware drain pipe, 6ins. in diameter, and filled with clinker which had passed a one-inch mesh sieve and had been rejected by one of half-inch mesh. The one which was intended to act as a percolating filter was arranged to drain from the bottom in the usual way, but the other was fitted with a diffuser, so that air could be passed through the media, and also with an outlet pipe, by means of which the liquor from the bottom of the filter could be continuously withdrawn. The latter pipe worked as a syphon, and was arranged to keep the media always submerged. As an afterthought, during the course of this investigation it was decided to endeavour to ascertain to what extent the results were affected by the media of the "aerofilter" by operating side by side a similar pipe without any media.

At the commencement of the investigation the filters were operated at a rate equivalent to approximately 100 gallons per cubic yard per day, and this quantity was increased from time to time as results warranted. Nitrates were obtained in the "aerofilter" after six months in the percolating filter after seven months, and in the pipe without media after eight months from the start.

The results obtained up to this point in the investigation are given in the following table :—

Results in grains per gallon.

	Settled sewage	Percolating filter effluent	"Aerofilter" effluent	"Pipe" effluent
Four hours oxygen absorption	5·12	2·16	1·62	2·00
Percentage purification	—	58%	68%	61%
Albuminoid ammonia	0·40	0·215	0·15	0·215
Percentage purification	—	46%	62%	46%
Nitrite (in terms of NH_3) ..	—	0·015	0·075	0·015
Nitrate (in terms of NH_3) ..	—	0·21	0·32	0·09
Putrescibility	—	47/252	7/251	30/222
Biochemical oxygen demand (Royal Commission test) ..	—	3·33	1·27	2·49
Volume treated (gallons per cubic yard per day)	—	129	177	130

As by this time all three plants were vigorously nitrifying, the flows were gradually further increased, until finally the percolating filter was dealing with an average of 242 gallons per cubic yard per day, the "aerofilter" with an average of 306 gallons, and the filter without media with 205 gallons. The average results of the analysis of the effluents obtained over a two-month period when operating at these rates are as follows :—

Results in grains per gallon.

	Settled sewage	Percolating filter effluent	"Aerofilter" effluent	"Pipe" effluent
Four hours oxygen absorption	5·71	1·74	1·66	2·46
Percentage purification	—	70%	71%	57%
Albuminoid ammonia	0·445	0·165	0·14	0·235
Percentage purification	—	63%	69%	47%
Nitrite (in terms of NH_3) ..	—	0·02	0·075	0·015
Nitrate (in terms of NH_3) ..	—	0·23	0·48	0·15
Putrescibility	—	½/58	1/58	7½/58
Biochemical oxygen demand Royal Commission test) ..	—	1·97	1·21	2·91
Volume treated (gallons per cubic yard per day)	—	242	306	205

From these results it will be seen that the aerofilter "matured" earlier than the percolating filter, but otherwise the results obtained, despite the fact that an excessive air supply was employed, were not sufficiently better than those obtained from the percolating filter to suggest any economic advantage. The results from the pipe without media are surprising, inasmuch as they show a much higher purification than might have been expected, and are interesting in indicating the effect of the surface contact afforded by the media.

The average air supply to the "aerofilter" and "control" pipe was approximately equal to 22 cubic feet per square foot of filter floor area, and, unfortunately, the conditions of experiment did not allow of the certainty of a regular supply of a less volume of air. For this reason these experiments cannot be considered as conclusively determining the practicability or otherwise of the application of submerged aerofilters as an economic means of preliminary treatment of " strong " or " difficult " sewages prior to final purification on percolating filters or by the activated-sludge process, although they would appear to suggest that as a means of the complete purification of sewage the aerofilter is unlikely to compete successfully and economically either with percolating filters or the activated-sludge process.

The results obtained are, however, considered of sufficient interest to justify publication and to warrant extension of this investigation on a scale large enough to ensure careful and accurate control of the air supply, which, if the method is to be economically applicable for the preliminary treatment of sewage, must, of necessity, be low in relation to the volume of sewage treated.

Sludge Disposal.

The work referred to in the last Report in respect of the possibility of the economic application of the process of secondary fermentation of sludge, with recovery of the gaseous products, as an alternative to the dewatering and drying of activated sludge with the production of a fertiliser of direct value to agriculture, has received further consideration during the year under review.

The knowledge thus gained has been supplemented by the information received during the course of a recent visit (July, 1928) of a deputation from the Committee to Germany, where there are many examples of this method of sludge disposal in successful and economic operation.

At the moment this issue is not of any great urgency, but sufficient information has now been accumulated to warrant adoption, if the need of such arises, of this means of sludge disposal, either as an auxiliary to or in substitution of the present methods of disposal, viz., sea disposal and direct disposal on land.

Microbiology of Activated Sludge.

A resumé of observations and studies made over a prolonged period in respect of the significance of the presence of protozoa in activated sludge is given in Appendix I. to this Report.

Effect of Iron Compounds in the Activated-Sludge Process.

A detailed account of an investigation of the debatable question of the influence of the presence of iron compounds in sewage in relation to the application of the activated-sludge process is given in Appendix II. to this Report.

Concluding Remarks.

It will be seen from the foregoing report that the utilisation of the land area at Flixton has given great relief to the general situation in respect of the problem of sludge disposal at the Main Outfall Works, Davyhulme. The adoption of this auxiliary means of sludge disposal has deferred the necessity of considering the question of running a second steamer for sea disposal, especially as the disposal capacity of this land could, at any time, be materially increased by preliminary secondary digestion of the sludge, as practised at Birmingham and in Germany.

The construction of the new detritus tanks and screening chamber is now completed, and this plant should shortly be fully equipped and brought into commission.

A new laboratory has been built during the year, and is now almost ready for occupation.

The modification in the design of the activated-sludge units (referred to in the last Report), included in the extension scheme in progress at the Davyhulme Works, and their transference to a new and more suitable site has been approved by the Ministry of Health. The preliminaries—preparation of detailed drawings, specifications, etc.—necessary to obtain tenders for this portion of the scheme are well advanced, and it is expected that this work will be put in hand in the near future.

On behalf of the Rivers Committee,

T. R. Hewlett,
Deputy-Chairman.

17th September, 1928.

APPENDIX I.

Activated Sludge Process.

Microbiological Studies.

From time to time, since 1914, microbiological studies of activated sludge have been undertaken, in connection with the treatment of sewage by the activated-sludge process, at both the Davyhulme and the Withington Works.

The studies fall conveniently under three heads :—

1. Types of protozoa occurring in activated sludge under different working conditions.
2. The influence of protozoa on the phenomenon of "bulking" of sludge.
3. The function of protozoa in the purification process.

1. *Types of protozoa occurring in activated sludge under different working conditions.*

Numerous microscopic examinations of activated sludge at both the Davyhulme and Withington Sewage Works have tended to confirm the opinion expressed in 1914, that no type of higher organism appeared to have any particular function in connection with the purification process, but, rather, the several species of protozoa occurring were indicative of the condition of the sludge.

As a result of the many examinations of sludge made, the following protozoal characteristics of sludges of varying qualities have become generally recognised in the Davyhulme and Withington laboratories :—

(A) *Sludge in bad condition.*

Preponderance of Flagellates, Amœbae (and other Rhizopods): relatively few Ciliates, *e.g.*, Carchesium, Chilodon : Chœnia absent.

(B) *Sludge in unsatisfactory condition.*

Flagellates, Amœbae (and other Rhizopods) : some Ciliates, *e.g.*, Stentor, Paramœcia, Chilodon, Carchesium, Vorticelli : Chœnia absent.

(C) *Sludge in satisfactory condition.*

Few Flagellates and Amœbae (and other Rhizopods) : preponderance of Ciliates, *e.g.*, Carchesium, Vorticelli, Chilodon, Colpoda, Colpidium : some Aspidisca and Loxophyllum : occasionally Chœnia : few Suctoria.

(D) *Sludge in good condition* (e.g., *when nitrification is well established*).

Very few Flagellates : Amœbae rare : preponderance of Ciliates, *e.g.*, Carchesium, Vorticelli, Aspidisca, Loxophyllum, Chœnia : few Suctoria.

The actual number of organisms present in sludge have rarely been determined. In general it has been found, however, that sludges of types (A), (B), and (C) are more thickly populated than sludges of type (D), and, as may be expected, that sludges dealing with domestic sewage are usually richer in protozoa than those dealing with sewage containing inhibitory trade waste.

(2) *Influence of protozoa on the phenomenon of "bulking" of sludge.*

Reference to some of the work carried out in this connection has already been made in a previous publication,* in which it was stated that "when the phenomenon of 'bulking' occurred microscopical examination of the sludge usually revealed a preponderance of certain types of higher organisms, such as, *e.g.*, Carchesium, Stentor, and filamentous growths of the Cladothrix type."

The investigations described in the paper established that "under suitable aeration conditions the control of the process could be well maintained without reference to the higher organisms contained in the sludge."

This conclusion was based on field observations extending over a considerable period of time, during which period numerous and periodic microscopical examinations of the activated sludge of a large-scale activated-sludge plant were made, and, on the fact that, under the aeration conditions provided, no trouble with respect to "bulking" had occurred, despite the occurrence on several occasions of abundant growths of protozoa, etc.

This view receives some corroboration from the following laboratory experiment, which had for its object a comparison of the changes of sludge volumes occurring during the purification of sewage, under adequate aeration conditions, using, in one case, sludge containing a minimum of protozoa, and, in the other, an equal volume of the same sludge to which had been added, at the commencement of the experiment, a large number of clusters of Carchesium.

> For the experiment, two glass vessels (capacity, 2–3 litres), fitted with diffusers and adapted for the treatment of sewage by the activated-sludge process on the "fill and draw" principle, were taken. To one vessel (A) was added a nitrifying sludge which had been previously built up with care, and contained relatively few protozoa. To the second vessel (B) was added an equal volume of the same sludge and 600–700 large-sized clusters of Carchesium freshly isolated from activated sludge. Both sludges were then treated with successive volumes of sewage over several weeks—allowing a volume of 700 cc.'s of liquor (sludge and effluent) to remain after each decantation and adding 1,600 cc.'s of sewage at each filling.
>
> For the first three days of experiment two fillings per day were allowed; subsequently, the number of fillings was increased to four and later five, (per day). The volume of air used for aeration of the mixtures of sludge and sewage was in each case, as nearly as possible, the same; and in amount was, as previously established by experiment, adequate for proper aeration and mixing of the sludge and sewage.
>
> When the volumes of sludge required to be reduced owing to accumulation with repeated fillings, a definite volume ($\frac{1}{7}$ or $\frac{2}{7}$) of sludge was discarded in each case, and replaced by an equal volume of effluent; and as many as possible of the clusters of Carchesium contained in the surplus sludge (B) were reisolated and returned to the sludge contained in the aeration vessel.

The results of the experiment are given in Table I., from which it will be seen that, under the aeration conditions obtaining, Carchesium in abundance had practically no influence on the settling properties of the sludge throughout the experiment.

---

* Activated Sludge Process—Withington Works—Ardern and Lockett. J.S.C.I., 1923, p.p. 225T–230T.

(3) *The function of protozoa in the purification process.*

In these experiments samples of activated sludge, rich in protozoa, were taken, and subjected to treatment with toluene vapour, in order to destroy the active organisms present, and without, if possible, altering the physical character of the sludge.

A comparison was then made of the purification of sewage effected by the treated sludges and by samples of the same sludges untreated.

The procedure in general was as follows :—

> A quantity (four litres) of mixed liquor was taken from an activated-sludge plant and divided into two portions, (A) and (B), which were poured into two aerating vessels similar to those previously described.
>
> Through portion (A), air impregnated with toluene vapour was passed for 2–3 hours, *i.e.*, until it was established by microscopic examination of samples withdrawn that no active protozoa were present. The mixture was then settled and the supernatant liquor removed from the sludge by decantation. Meanwhile, portion (B) was aerated in the usual manner, settled, and the supernatant liquid also removed.
>
> The sludges were then treated with active protozoa-free activated-sludge effluent (or dil. sewage).* After a short aeration period the mixtures were again allowed to settle and the supernatant liquids removed.
>
> Subsequently the sludges were treated with successive volumes of sewage (active protozoa-free), with suitable or convenient periods of aeration.

The experiment was continued so long as the toluened sludges remained free from active protozoa. All effluents were inspected and, when thought desirable, subjected to chemical analysis.

The results of three experiments along these lines are given in Table II., from which it will be seen that—

1. Treatment of activated sludge with toluene vapour as described invariably affected to some extent the physical properties of the sludge, with the result that the effluents for the first few fillings were slightly turbid.
2. After a few days, effluents of similar quality, as indicated by chemical analysis, were produced by both the active-protozoa-free sludge and the sludge of the control.
3. So long as the toluened sludges remained free from active protozoa, the effluents produced were always slightly less clear than those of the control experiment.
4. In two experiments, when the effluents from the toluened and control sludges became alike in appearance, protozoa (flagellates) simultaneously developed in the toluened sludge.

With respect to (3) it was thought possible that had the period of protozoal sterility been prolonged, the effluents from the treated and untreated sludges would ultimately have become exactly alike. On the other hand there were the two striking instances, mentioned in (4), of perfect clarity being attained simultaneously with the appearance of flagellates.

---

* The effluents and sewages used were rendered free from active protozoa by treatment with hydrochloric acid overnight. Before using, the original alkalinity of the sewage or effluent was restored by addition of an equivalent amount of sodium carbonate.

TABLE 1.—*Effect of Carchesium Growths.*

PERIOD	Filling number	Percentage sludge as measured after 1 hour in				Numbers of Carchesium clusters in sludge in use		Parts per 100,000													
								Average composition, during period, of :—													
		Cylinders		Bottles				Sewage				Effluents									
								4 Hours oxygen absorption	Free and saline ammonia	Albuminoid ammonia	Alkalinity (as $CaCO_3$)	4 Hours oxygen absorption		Free and saline ammonia		Albuminoid ammonia		Nitrite and Nitrate (as NH_3)		Alkalinity (as $CaCO_3$)	
		A	B	A	B	A	B					A	B	A	B	A	B	A	B	A	B
1. (2 Fillings per day)	At start April 20th	18·5	19·0	...	...	...	600-700	6·22	4·38	1·17	26·5	·73	·80	·60	·67	·17	·185	2·96	2·96	6·0	6·0
	8	23·0	24·0	27·0	27·0	...	...														
2. (4 Fillings per day)	22	...	...	...	...	None visible	896	4·07	2·73	·86	19·5	·66	·66	1·32	1·39	·16	·16	·99	1·03	13·0	13·0
	41	16·5	17·0	20·0	20·0	ditto	924														
	53	17·0	17·0	21·5	21·5	ditto	1400														
	59	15·0	15·0	...	...	ditto	Large number														
3. (5 Fillings per day)	64	...	...	...	...	One in 100 cc visible	434	5·34	3·54	1·13	21·5	·79	·74	1·17	1·26	·17	·18	1·17	1·23	15·0	16·0
	79	18·0	19·0	23·0	24·0	...	...														
	May 15th 89	15·4	15·4	...	...	None visible	Large number visible														
4. (4 Fillings and non-aeration period of 6-8 hours per day)...	94	23·0	23·0	25·0	25·0	...	...	6·17	4·50	1·42	26·5	·90	·96	1·67	1·67	·20	·205	1·20	1·14	13·5	13·5
	105	23·5	23·0	29·5	27·5	...	...														
5. (5 Fillings and non-aeration period of 9 hours per day) ...	May 26th 130	18·0	18·0	...	...	...	...	5·60	4·57	1·26	30·0	1·03	1·14	1·86	1·89	·18	·205	1·48	1·40	16·5	16·0

Microscopical examination after Filling 89 :—

A—Large numbers of aspidisca : few isolated minute colonies of carchesium and 1 only large colony : few chœnia.

B—Great preponderance of carchesium : aspidisca.

Table II.

Function of Protozoa in the purification process.

Experiment 2.

Filling	Appearance of effluents		Analysis (parts per 100,000)					Microscopical examination of sludge A
			4 Hours oxygen absorption					
	A (Toluened sludge)	B (Control)	Raw sewage	Effluents				
				A		B		
				shaken	filtered	shaken	filtered	
1	Fairly turbid	Clear	..	..	..	..	..	Free from active protozoa
3	Slightly turbid	Clear	1·49	1·34	..	·94	..	
6	Slightly turbid	Clear	4·52	1·09	..	1·00	..	No active protozoa
10	..	..	..	..	..	..	..	No active protozoa
11	Slightly turbid	Clear	3·37	·68	..	·60	..	
19	Slightly turbid	Slightly turbid, but clearer than effluent A	..	..	..	..	..	
22	Very slightly turbid	Clear	6·86	1·14	..	1·23	..	
25	Very slightly turbid	Clear	9·54	·97	·83	1·06	·83	No active protozoa, but several circular bodies
27	Very slightly inferior to B	Clear	..	..	..	..	..	
28	Very slightly inferior to B	Clear	..	·63	..	·66	..	
34	Clear	Clear	..	..	..	..	..	Numerous active protozoa (flagellates)

Remarks: Total time for experiment, 10 days. Three to four fillings per day.

TABLE II.—*continued*

Function of Protozoa in the purification process—continued

Experiment 3.

Filling	Appearance of effluents		Analysis (parts per 100,000									Microscopical examination of sludge A
			4 Hours oxygen absorption					Albuminoid ammonia		Nitrite and nitrate		
				Effluents				Effluents		Effluents		
	A (Toluened sludge)	B (Control)	Raw sewage	A		B						
				shaken	filtered	shaken	filtered	A	B	A	B	
1	Turbid	Slightly turbid	..	..	..	..	..	..	..	..	..	No active protozoa
5	Much improved	Clear	7·71	·94	..	·83	..	..	..	..	..	No active protozoa
10	Slightly turbid	Clear	7·31	1·12	·91	1·03	·83	..	..	..	..	No active protozoa
12 After one hour aeration	Fairly clear	Fairly clear	4·97	1·14	..	1·03	..	..	..	..	..	No active protozoa
After three hrs. aeration	Very slightly turbid	Fairly clear	..	·97	·74	·86	·74	·31	·22	·16	·11	No active protozoa
one hour	Fairly clear	Fairly clear	5·54	·74	..	·80	..	..	..	..	..	No active protozoa
three hours	Very slightly turbid	Fairly clear	..	·88	·72	·86	·68	·205	·145	..	..	No active protozoa
25	....	....	..	..	..	..	..	..	..	..	..	Few flagellates present
29	Very nearly equal to B	Clear	..	..	..	..	..	..	..	..	..	Presence of flagellates in numbers definitely established
31	Clear	Clear	5·60	·83	·80	·97	·90	·25	·265	..	..	

Remarks: Total time for experiment, eight days. Four to five fillings per day.

Experiment 4.

Function of Protozoa in the purification process—continued

Filling	Appearance of Effluents		Analysis (parts per 100,000)							Microscopical examination of sludge A
			4 Hours oxygen absorption					Albuminoid ammonia		
				Effluents				Effluents		
	A (Toluened sludge)	B (Control)	Raw sewage	A		B		A	B	
				shaken	filtered	shaken	filtered			
1	Turbid	Clear	..	..	..	..	..	..	..	No active protozoa
6	Very slightly turbid	Fairly clear	..	..	·80	..	·88	..	..	
11	Very slightly turbid	Fairly clear	..	..	..	..	..	..	..	Few small bodies. No moving protozoa
14 After one hour aeration	Slightly turbid	Slightly turbid	7·03	1·13	..	·97	..	..	..	
After two hours aeration	Very slightly turbid	Very little better than A	..	1·06	..	·92	..	·22	·20	
16	Slightly turbid	Very little better than A	..	..	..	..	..	..	..	Small circular bodies. No moving protozoa
27 one hour	Slightly turbid	Very little better than A	5·60	1·06	..	·97	..	..	..	
two hours	Slightly turbid	Very little better than A	..	·97	·86	·97	·77	..	..	
36	Slightly turbid	Very little better than A	..	..	..	..	..	..	..	Large number of flagellates
42	Very clear	Very clear	..	1·14	..	1·12	..	·205	·215	Large number of flagellates

Remarks: Total time for experiment, ten days. Five to seven fillings per day.

Unfortunately, further attempts to maintain, over a prolonged period, a sludge entirely free from protozoa proved abortive, mainly by reason of "spore" or "cyst" formations, and consequently the precise connection, if any, between the presence of protozoa in the sludge and very high clarity of effluents has not been definitely established.

The following points emerge from the foregoing investigations:—

1. That the different species of protozoa found in activated sludge are indicative of the condition of the sludge

2. That in the treatment of sewage by the activated-sludge process, under suitable aeration conditions, protozoa have no adverse influence on the settling properties of the sludge.

3. That, from the standpoint of sewage treatment in general, protozoa play no important part in the process of purification by activated sludge, although it is possible they facilitate the production of a more highly clarified effluent. This table appears to support the observation of Haigh Johnson* that paramœcia accompanied effluents of unusual purity and the suggestion that protozoa help in the removal of fine particles of suspended matter and the surplus bacteria, but this investigation has not included any experiments designed to demonstrate such a relationship between protozoal and bacterial content of the final effluent.

---

* Proc. Man. S.D. Works Assoc., 1922, p. 54.

APPENDIX II.

The effect of iron compounds on the treatment of sewage by the Activated Sludge process.

The possibilities of the use of hydroxides of iron and aluminium in connection with the initial production of activated sludge from sewage were investigated in 1915. The experiments indicated that no material advantage was to be obtained by the employment of such hydroxides[1]. Other experiments, carried out at about the same time, having reference to the possible catalytic action of iron (and manganese) salts in the process of sewage purification by aeration and activated sludge, yielded negative results[1].

In 1922, in experiments relating to the " bulking " of sludge, an attempt was made to reduce a " bulked " sludge by making use of the known coagulative properties of iron salts. In this connection iron salts were of no avail—the addition of ferric chloride in increasing but reasonable amounts to sewage did not result in a permanent reduction in the volume of sludge, but rather tended to an increase. In the course of these experiments it was observed that the treatment of sewage with ferric chloride prior to aeration with activated sludge resulted in a better effluent.

At a later period it was observed that the addition of aluminium sulphate to sewage, prior to aeration with activated sludge, resulted in the rapid production of a good class effluent.

In a paper by Scouller[2] in December, 1926, reference was made to the effect of chemical effluents containing salts of iron and aluminium on the purification of sewage by activated sludge, and the conclusion was drawn that acids and salts of iron and aluminium inhibit or retard the purifying action of activated sludge.

Wolman[3], in 1927, after reviewing the work of Warburg in connection with the function of iron as the oxygen-carrier of respiration-ferment, and that of Horowitz and Vlassowa on the influence of hydroxides of iron and alumina on the purification, referred to a few indefinite results obtained by him at Maryland, and stated "there is some theoretical and some practical foundation for assuming that iron may be helpful both as an oxygen-carrier and as an absorbent and coagulant," and "from a superficial survey of the activated sludge plants in this country (U.S.A.) and abroad, those which have given least difficulty in operation dealt with a raw sewage which contained appreciable quantities of iron."

With the view of obtaining more precise information on this subject the following experiments have been carried out at the Withington Sewage Works.

The apparatus used was similar to that employed in previous investigations, and consisted essentially of glass vessels, capacity 2–3 litres, fitted with " diffusers," and adapted for the treatment of sewage by the activated sludge process on the " fill and draw " principle. The sewage used was the domestic sewage draining to the Withington Works.

The effect of "ferric" iron, in the form of ferric chloride, upon the purification process.

In the first series of experiments the effect of the addition of one and two parts per 100,000 of ferric iron (in the form of ferric chloride) on the purification process was studied, using activated sludge which was capable of producing clear and satisfactory effluents but no nitrification. These experiments were subsequently extended to embrace a study of the effect of three and four, five and six, and ultimately ten parts per 100,000 of iron.

---

[1] Ardern and Lockett, 1915, J.S.C.I.

[2] Surveyor, 1926, p. 537. Pro. Ass. Managers of Sewage Works, 1926, p. 126.

[3] Eng. News Rec., 1927, *98*, p. 202.

The procedure adopted was as follows:—Three aerating vessels were taken, and to each was added a definite volume of a sample of activated sludge. One sludge was used in the control experiment, *i.e.*, for the treatment of successive volumes of sewage without any added reagent, and the other sludges for the treatment of successive volumes of the same sewage to which had been added the required amount of iron salt. A six-hourly cycle of operations was continued over several days. The cycle comprised a three hours aeration period and a three hours period for settlement of the sludge, decantation of purified sewage, and for the refilling of the aeration vessels. When the investigation had proceeded sufficiently far for the requirements of the study all sludges were treated with sewage without chemicals for a few days, to study the effect of the added salts upon the normal properties of the sludge.

Sewages and effluents (after three hours aeration) were subjected to analysis, and on occasions, to show better the effect of the added chemicals, samples were taken after twenty minutes, half-hour, one hour, etc., as required. Typical results obtained in these experiments are given in Table I.

These results show that the addition of one to six parts of iron (in the form of ferric chloride) to samples of Withington Sewage, prior to mixing with activated sludge and aerating, resulted in effluents superior to those obtained in the usual manner; the effect being proportional to the amount of iron used.

On discontinuing the addition of iron to the sewage and using the "iron" sludges for the treatment of sewage without added reagent, no difficulty was encountered in obtaining satisfactory effluents. Sometimes, for a short period, the effluents continued to be slightly superior to the effluents of the control, but generally, they were of similar quality.

From the results given in Table I. with respect to the effect of ten parts per 100,000 of ferric iron it will be seen that excellent effluents in this case also were obtained. On discontinuing, however, the addition of the iron the effluents became turbid, and even at the end of a large number of additional fillings the turbidity had not entirely disappeared.

This interference with the normal working of the process is attributed to the periodic lowering of the pH of the mixed liquor (by reason of the amount of iron salt employed) to the neutral point or beyond.

The effect of "ferrous" iron (in the form of ferrous sulphate) on the purification process.

Experiments in which iron in the form of ferrous sulphate was added to sewage, prior to mixing with activated sludge and aerating, showed that iron in the ferrous state also facilitates the purification of sewage by the activated sludge process; but, in this respect, it is by no means as effective as ferric iron—actually, five parts of ferrous iron is not as effective as two parts of iron in the form of ferric chloride.

Some of the results obtained in this series of experiment are given in Table II.

The effect of "ferric" and "ferrous" iron upon the purification of sewage with nitrification, by the Activated Sludge process.

The effect of "ferric" and "ferrous" iron on the purification of sewage, when using activated sludge capable of nitrification, was determined by experiments carried out on lines similar to those previously mentioned, using in one case five parts of iron (in the form of ferric chloride), and in the other one and two parts of iron (in the form of ferrous sulphate).

When viewed from the standpoint of the four hours oxygen absorption and albuminoid ammonia tests, the results obtained were similar to those of the preceding experiments, but no definite evidence was obtained to show that treatment with iron salts accelerated the process of nitrification, since all sewages, *i.e.*, sewages both with and without reagent, were nitrified at approximately the same rate.

Typical results of these experiments are given in Table III.

Effect of 'Ferric' Iron (in the form of ferric chloride) on the purification of sewage by the Activated Sludge process. Results in parts per 100,000.

	Series 1 (a)—Filling No. 49							Series 1 (b)—Filling No. 16.			Series 1 (b)—Filling No. 31.						
	SEWAGE	EFFLUENTS						EFFLUENTS			SEWAGE	EFFLUENTS					
		After 40 minutes aeration			After 3 hours aeration			After 3 hours aeration				After 20 minutes aeration			After 1 hours aeration		
		No reagent	1 part 'Fe'	2 parts 'Fe'	No reagent	1 part 'Fe'	2 parts 'Fe'	No reagent	3 parts 'Fe'	4 parts 'Fe'		No reagent	3 parts 'Fe'	4 parts 'Fe'	No reagent	3 parts 'Fe'	4 parts 'Fe'
Four hours oxygen absorption.	5·26	1·00	·77	·63	·71	·54	·49	·66	·49	·40	7·60	1·20	·60	·60	·86	·60	·49
Free and saline ammonia	3·57	3·21	3·36	3·21	2·86	2·93	2·93	1·64	1·71	1·43	2·57	2·43	2·43	2·43	2·29	2·36	2·29
Albuminoid ammonia...........	·94	·36	·31	·25	·25	·21	·20	·16	·15	·135	1·30	·31	·20	·17	·17	·15	·15
Nitrite and nitrate (as NH_3)	—	—	—	—	·07	·07	·07	·02	·03	·03	—	—	—	—	·10	·10	·10
Alkalinity (as $CaCO_3$)	25·0	24·0	23·0	22·0	24·0	21·0	19·0	20·0	11·0	8·0	20·0	20·0	15·0	13·0	20·0	13·0	12·0

	Series 1 (c)—Filling No. 24			Series 1 (c)—Filling No. 25							Series 1 (d)—Filling No. 20				
	EFFLUENTS			SEWAGE	EFFLUENTS						SEWAGE	EFFLUENTS			
	After 3 hours aeration				After 20 minutes aeration			After 1 hours aeration				After 40 minutes aeration		After 1 hour 20 minutes aeration	
	No reagent	5 parts 'Fe'	6 parts 'Fe'		No reagent	5 parts 'Fe'	6 parts 'Fe'	No reagent	5 parts 'Fe'	6 parts 'Fe'		No reagent	10 parts 'Fe'	No reagent	10 parts 'Fe'
Four hours oxygen absorption	1·12	·66	·63	7·77	1·86	·92	·80	1·57	·80	·74	4·12	1·09	·60	1·03	·57
Free and saline ammonia	3·57	3·50	3·29	4·00	3·86	3·80	3·86	3·50	3·57	3·64	4·21	4·50	4·57	4·78	4·57
Albuminoid ammonia...........	·26	·165	·13	·77	·45	·21	·21	·34	·17	·17	·97	·31	·16	·28	·18
Nitrite and nitrate (as NH_3)..	·09	·06	·06	—	—	—	—	·07	·07	·07	—	—	—	·07	·07
Alkalinity (as $CaCO_3$)	30·0	15·0	13·0	30·0	29·0	16·0	14·0	28·0	16·0	14·0	25·0	24·0	9·0	24·0	9·0

TABLE II.

Effect of "ferrous" iron (in the form of ferrous sulphate) on the purification of sewage by the Activated Sludge process.
Results in parts per 100,000.

	Filling No. 8						
		Effluents					
	Sewage	After ½ hour aeration			After 3 hours aeration		
		No reagent	2 parts "Fe" (ferrous)	2 parts "Fe" (ferric)	No reagent	2 parts "Fe" (ferrous)	2 parts "Fe" (ferric)
Four hours oxygen absorption	4·57	·94	·80	·63	·80	·66	·54
Free and saline ammonia ..	3·28	3·09	3·07	3·07	2·65	2·65	2·65
Albuminoid ammonia	·79	·34	·25	·20	·265	·25	·20
Nitrite and nitrate (as NH_3)	—	—	—	—	·07	·06	·06
Alkalinity (as $CaCO_3$)	22·0	20·0	18·0	16·0	20·0	17·0	15·0

	Average results: Fillings Nos. 1 and 5				Average results: Fillings Nos. 1, 5, and 16			
		Effluents				Effluents		
	Sewage	After ½ hour aeration			Sewage	After 3 hours aeration		
		No reagent	5 parts "Fe" (ferrous)	2 parts "Fe" (ferric)		No reagent	5 parts "Fe" (ferrous)	2 part "Fe (ferric
Four hours oxygen absorption	5·48	1·23	·80	·80	5·80	·83	·76	·64
Free and saline ammonia	5·36	5·28	5·14	5·14	5·36	5·07	4·93	4·93
Albuminoid ammonia	1·14	·56	·43	·36	1·20	·385	·385	·30
Nitrite and nitrate (as NH_3)	—	—	—	—	—	·10	·09	·07
Alkalinity (as $CaCO_3$)	26·0	25·0	20·0	22·0	27·0	25·5	18·5	21·5

TABLE III.

The effect of 'ferric" and "ferrous" iron on the purification of sewage with nitrification by the Activated Sludge process. Results in parts per 100,000.

	Filling No. 28					Average of fillings Nos. 36 and 39.				
	Sewage	Effluents				Sewage	Effluents			
		After 1 hours aeration		After 2 hours aeration			After $\frac{1}{2}$ hour aeration		After $2\frac{1}{2}$ hours aeration	
		No reagent	5 parts "Fe" (ferric)	No reagent	5 parts "Fe" (ferric)		No reagent	2 parts "Fe" (ferrous)	No reagent	2 parts "Fe" (ferrous)
Four hours oxygen absorption	4·46	·83	·54	·80	·43	5·12	·93	·77	·90	·70
Free and saline ammonia	4·72	2·00	2·14	·93	1·07	4·21	2·24	2·46	·93	1·07
Albuminoid ammonia	·87	·16	·14	·14	·11	·87	·20	·19	·13	·12
Nitrite and nitrate (as NH_3)	—	1·18	1·07	2·21	2·14	—	·43	·51	1·18	1·22
Alkalinity (as $CaCO_3$)	27·0	18·0	8·0	10·0	4·0	26·0	21·5	19·0	14·0	11·0

In endeavouring to find an explanation of the beneficial effect of the presence of iron salts in the sewage the problem was studied from several points of view, viz.:—

(*a*) Iron compounds possibly acting as oxygen carriers.

(*b*) The possibility that the partially clarified liquor immediately resulting from the addition of the iron salts was more readily oxygenated than the colloidal mixed liquor in the control experiment without reagent.

(*c*) Effect of the lowering of the *p*H of the mixed liquor by the addition of the iron solution, and

(*d*) Effect, *per se*, of the co-precipitate formed by a combination of sewage compounds and the reagent.

Stated briefly, the following are the results of this further inquiry:—

(*a*) No evidence was obtained which would suggest that the iron compounds acted as oxygen carriers.

(*b*) The rate of oxygenation of clear water was no higher than that of colloidal solutions such as dilute starch solution and colloidal silica solutions.

(*c*) Lowering of the *p*H of the sewage by the addition of acid, precisely to that produced by the addition of the iron salts, had no beneficial effect on the rate of purification.

(*d*) Experiments in which freshly precipitated iron hydroxide was introduced with the sewage treated showed a marked increase in the rate of removal of oxidisable matters, as measured by the four hours' oxygen test, as compared with the control experiment operating under normal conditions. In fact, iron, added in this form, accounted for approximately one-half the improvement observed when the same quantity of ferric iron was employed in the form of ferric chloride.

Summary.

The results of this investigation may be summarised as follows:—

1. That the presence of either ferrous or ferric salts in sewage increases the rate of removal of oxidisable matter by the activated-sludge process, the increased purification effect being more or less proportional to the amount of iron salts present; ferric salts are much more effective than ferrous salts in this respect. If, however, the iron salts are present in amount sufficient to lower the *p*H of the sewage below neutrality, the normal purifying properties of the sludge are impaired, so that, if the addition of iron compounds is stopped, turbid effluents result.

2. The presence of iron salts in the sewage does not accelerate nitrification.

3. The evidence goes to show that the increase in the purification effect is a function of the coagulative power and precipitate forming properties of these reagents.

Practical application.

Experimental trials have determined that an addition of ferric salts (ferric chloride) to the extent of five parts of iron per 100,000 parts of sewage is required to reduce by one-half the average aeration (detention) period required for the continuous production of a satisfactory effluent from the domestic sewage received at the Withington Works.

Unfortunately, in this amount (approximately two-thirds of a ton of ferric chloride per million gallons of sewage treated) the use of ferric chloride as an adjunct to the activated sludge process is impracticable.

The question of the use of iron salts in association with the activated sludge process, however, appears to be worthy of more extended consideration, possibly more particularly in connection with the treatment of "strong" and/or "difficult" sewages, and especially so since there is some prospect of substituting a less costly coagulant than ferric chloride.

The Research Chemist (W. J. Lockett, M.Sc.), has been responsible for the conduct of the experimental investigations described in these two appendices, and also for the control of the activated-sludge units at the Withington Works, whilst the Resident Chemist (C. Jepson, M.Sc., A.I.C.) was responsible for the work carried out at the Davyhulme Works relative to the activated-sludge process, and for the aero-filter investigation described in the body of the report. The whole of this work is subject to the direction of the Consulting Chemist.

LIST OF TABLES AND DIAGRAMS.

Table	I.	General Rivers Work ..	.. Details of Expenditure.
,,	II.	Withington Sewage Works	.. Details of Expenditure.
,,	III.	Moss Side Sewage Works	.. Details of Expenditure.
		Middleton Sewage Works	.. Details of Expenditure.
		Gorton Sewage Works ..	.. Details of Expenditure.
,,	IV.	Davyhulme Sewage Works	.. Details of Expenditure and Sewage Treatment Statistics.
,,	V.	Do.	.. Summary of Statistics.
,,	VI.	Do.	.. Comparative Annual Costs, etc., for the Period of 1924-25 to 1927-28.
,,	VII.	Do.	.. Composition and Volume of Raw Sewage and Unfiltered Tank Effluent.
,,	VIII.	Do.	.. Primary Beds—Quantity dealt with, and Composition of Filtrate.
,,	IX.	Do.	.. Secondary Bed No. 10A—Quantity dealt with, and Composition of Filtrate.
,,	X.	Do.	.. Secondary Bed No. 1—Quantity dealt with, and Composition of Filtrate.
,,	XI.	Do.	.. Secondary Beds Nos. 5 to 19—Quantity dealt with, and Composition of Filtrate.
,,	XII.	Do.	.. Secondary Beds Nos. 2 and 20 to 27—Quantity dealt with, and Composition of Filtrate.
,,	XIII.	Do.	.. Secondary Beds Nos. 32 to 35—Quantity dealt with, and Composition of Filtrate.
,,	XIV.	Do.	.. Secondary Beds Nos. 36 to 39—Quantity dealt with, and Composition of Filtrate.
,,	XV.	Do.	.. Suspended Solids in Sewage and Effluents.
,,	XVI.	Do.	.. Composition of Ship Canal Water above and below the Effluent Outlet.
,,	XVII.	Do.	.. Particulars of Total Cost of Sewage Disposal, 1896 to 1928.
Diagram	1.	Daily Examination of Ship Canal Water above Outfall (Incubation Test only), together with Rainfall and Temperature Records.	
,,	2.	Results of Examination of Ship Canal Water above and below Outfall, and of Average Effluent (Incubation Test only).	

Table I.

GENERAL RIVERS WORK.

	£	s.	d.	£	s.	d.
ADMINISTRATION—						
Rivers Department	2,372	3	6			
Other Departments' charges	71	6	7	2,443	10	1
SURVEILLANCE OF RIVERS AND STREAMS AND TRADE EFFLUENTS				608	9	6
GREEN LANE DEPOT—						
Rents, Rates, Taxes, and Insurance	34	4	9			
Fabric Maintenance	5	5	1			
Tackle Maintenance	2	1	11			
General Cleaning and Sundries	9	12	9			
Workmen's Holidays	8	18	0	60	2	6
WESTHEAD'S WEIR—						
Routine Operation	55	17	5			
Maintenance	9	9	9	65	7	2
BIRLEY'S WEIR—						
Routine Operation	6	0	6			
Maintenance	9	5	6	15	6	0
WORK IN RIVERS AND STREAMS—						
River Medlock	86	5	6			
Corn Brook	21	16	4			
Gore Brook	1	3	7			
Moston Brook	0	10	10			
Nico Ditch	1	10	10			
Ball Brook	0	10	8			
Engineering Department Fares and Sundries	0	2	3			
Pike Fold Brook	1	3	8			
Ley Brook	0	11	7	113	15	3
CONTRIBUTION TO RIVERS MERSEY AND IRWELL JOINT COMMITTEE				1,950	0	0
INSPECTION OF RIVER BANKS				1	1	0
CULVERTING OF RIVERS AND STREAMS BY OWNERS. ENGINEERING DEPARTMENT'S SUPERVISION				33	5	7
WORK FOR OUTSIDE PARTIES (RECOVERABLE)				1	12	4
SETTLING BASIN ON RIVER MEDLOCK AT CLAYTON				5	0	0
UPPER MERSEY NAVIGATION EXPENSES				9	6	4
MAINTENANCE OF RIVER MEDLOCK INVERT				14	2	6
				5,320	18	3
Less :						
Rents and Privileges	*13*	*3*	*7*			
Sales of Sundry Materials	*4*	*6*	*8*			
Proportion of Cost of Rebuilding Retaining Wall at Coalbrook Street refunded	*250*	*0*	*0*	*267*	*10*	*3*
				£5,053	8	0

NOTE.—In comparing these costs with the charge on the rates (*see* page 5) the sum of £132 8s. 11d. (overlapping accounts) must be deducted.

WITHINGTON SEWAGE WORKS.

Table II.

Cost of Sewage Treatment, 1927-28.

	£	s.	d.	£	s.	d.	
SCREENS AND CATCHPITS—							£1,194 14s. 6d.
Routine Cleaning and Operation	171	10	2				
High-level Screen Maintenance	2	0	5				
Low-level Screen Maintenance	1	5	6				
Conical Catchpit Detritus Removal	54	14	7				
Conical Catchpit Manitenance	1	0	3				
				230	10	11	
SETTLEMENT TANKS—							
Routine Cleaning and Operation	123	5	5				
Emscher Tank Maintenance	33	7	3				
				156	12	8	
SLUDGE DISPOSAL ON LAND—							
Digging, Filling, and Covering Grips and Lagoons	369	17	0				
Ejector and Pipe Maintenance	13	7	6				
Emscher Sludge Beds and Drying Ground	208	1	8				
Ejector House Maintenance	0	16	7				
Electric Current and Supervision	26	9	9				
Power House Charges (Proportion)	107	12	5				
				726	4	11	
CONSTRUCTION OF NEW EMSCHER SLUDGE BEDS				81	6	0	
BACTERIA BEDS—							
Routine Operation	304	5	4				
Primary Beds; Medium Surface Maintenance	332	15	3				
Secondary Beds; Medium Surface Maintenance	311	16	6				
Storm Beds; Medium Surface Maintenance	67	8	5				
				1,016	5	6	
CARRIERS—							
Routine Cleaning	28	14	2				
Fabric Maintenance	0	16	0				
				29	10	2	
ACTIVATED-SLUDGE PLANTS—							
No. 1 Plant:							
Routine Operation	96	0	2				
Tank Fabric Maintenance	5	18	1				
Tank Equipment Maintenance	0	5	11				
No. 2 Plant:							
Routine Operation	134	14	4				
Tank Equipment Maintenance	0	9	8				
Electric Current and Supervision	729	10	6				
Power House Charges	215	4	10				
No. 1 (Jones & Attwood) Compressor Maintenance	37	17	10				
No. 2 (Jones & Attwood) Compressor Maintenance	13	2	3				
No. 3 (Tilghman) Compressor Maintenance	0	10	0				
Erection of Steam Diffuser Cleaning Plant	8	16	4				
				1,242	9	11	
STORM-WATER PUMP AND RESERVOIR—							
Pump Operation	32	19	9				
Pump Maintenance	4	17	5				
				37	17	2	
LABORATORY—							
Routine Work	529	14	0				
Activated-sludge Tests	1	11	6				
Sludge Digestion Experiments	40	2	6				
Building Maintenance	4	15	5				
				576	3	5	
RIVER BANK AND CHORLTON BROOK BANK MAINTENANCE				0	15	8	
ROAD MAINTENANCE				20	10	3	
FENCING				28	9	2	
GREASE RECOVERY				11	1	10	

	£	s.	d.	£	s.	d.
ADMINISTRATION—						
Routine Work	373	17	5			
Foreman's Emoluments	19	6	6			
Administrative Building Maintenance	0	12	6			
Foreman's House Maintenance	4	6	9			
				398	3	2
LAND CULTIVATION—						
Routine Work	402	14	5			
Implement Repairs	7	3	11			
				409	18	4
MONETARY ALLOWANCES—						
Sickness	27	2	7			
Workmen's Compensation	1	5	0			
Additional to Superannuation	47	9	0			
School Fees of Junior Assistant	3	13	6			
				79	10	1
COTTAGES—						
No. 1 Cottage Maintenance	2	14	5			
No. 2 Cottage Maintenance	3	9	10			
Tenancy Services	4	15	11			
				11	0	2
RENTS, RATES, TAXES, AND INSURANCE—						
Works	855	0	4			
Agricultural Land	44	1	9			
Meadows	9	11	8			
				908	13	9
PUMPING—						
Electric Current and Supervision	430	6	5			
Power House Charges	430	9	8			
No. 2 (10in.) Pump Maintenance	8	14	4			
No. 3 (10in.) Pump Maintenance	13	10	2			
No. 4 (15in.) Pump Maintenance	0	5	11			
				883	6	6
GENERAL BUILDING MAINTENANCE				26	9	4
SUNDRY UNCLASSIFIED ITEMS				32	7	2
				6,907	6	1
Less:						
Sale of Grease	*44*	*8*	*9*			
Sale of Farm Produce	*233*	*16*	*8*			
Farm Produce Consumed in Stables	*51*	*18*	*11*			
Sale of Sundry Materials	*16*	*4*	*3*			
Rents of Cottages and Meadows	*119*	*12*	*4*			
				466	*0*	*11*
				£6,441	5	2

	£	s.	d.
Average cost per million gallons	3	14	10·5
Average cost per million gallons for year ended 30th March, 1927	4	18	10
Average cost per head of population connected to sewers	0	1	8·8
Average cost per head of population connected to sewers for year ended 30th March, 1927	0	2	0

NOTE.—In comparing these costs with the charge on the rates (*see* page 5 £16 13s. 3d. (overlapping accounts and income tax adjustments) must be deducted.

Table III.

MOSS SIDE SEWAGE WORKS.

	£	s.	d.	£	s.	d.
BUILDING MAINTENANCE—						
Caretaker's Cottage	0	14	11			
Tenant's Cottage	1	17	4			
Outbuildings	5	13	3			
				8	5	6
SLUDGE LAGOONS				47	15	0
FENCING				0	5	11
GENERAL CLEANING AND SUNDRIES				11	1	9
CARETAKER'S EMOLUMENTS				7	1	10
RENTS, RATES, TAXES, AND INSURANCE				38	16	3
WATER—MAIN AND SERVICE PIPES MAINTENANCE				14	15	7
ADMINISTRATION				16	15	0
TENANCY SERVICES				2	7	1
				147	3	11
Less :						
Rent of House and Privileges	*62*	*1*	*10*			
Sale of Sundry Materials	*3*	*18*	*0*			
				65	*19*	*10*
				£81	4	1

In comparing these costs with the charge on the rates the sum of £13 6s. in respect of overlapping accounts and income tax adjustments must be deducted.

MIDDLETON SEWAGE WORKS.

	£	s.	d.	£	s.	d.
ADMINISTRATION				22	15	2
RENTS, RATES, TAXES, AND INSURANCE				31	7	9
FENCING				9	3	2
RECONDITIONING WORKS	1,236	12	2			
Less Sale of Sundry Materials	*17*	*13*	*2*			
				1,218	19	0
				1,282	5	1
Less : Rent of Building				*20*	*0*	*0*
				£1,262	5	1

In comparing these costs with the charge on the rates the sum of £88 0s. 4d. in respect of overlapping accounts must be deducted.

GORTON SEWAGE WORKS.

	£	s.	d.
CLEANING, FENCING, AND WEED DISPOSAL	11	7	6
ADMINISTRATION	15	15	0
RENTS, RATES, TAXES, AND INSURANCE	331	7	1
	£358	9	7

In comparing these costs with the charge on the rates the sum of 17s. 4d. in respect of overlapping accounts must be added.

DAVYHULME WORKS.

Table IV.

SLUDGE.

Period of 3 Months ending	Sludge Produced	Trips run by Steamer	Refuse from Screens
1927	Tons		Tons
June 29th	59,222	51	1,353
September 28th	41,369	43	1,362
December 28th	47,248	40	1,276
1928			
March 28th	49,953	36	1,051
Total for 52 weeks ending March 28th, 1928	197,792	170	5,042
Average per week (52 weeks)	3,804	3·27	96·96
Average per million gallons	10·62	...	0·27
Average for 52 weeks ending March 30th, 1927	12·65	Average per week 3·48	0·29
Average for 53 weeks ending March 31st, 1926	12·99	3·75	0·27

Memo.—170,319 tons deposited at sea; 6,723 tons pumped to Flixton and deposited on land; 20,197 tons water decanted from sludge storage tanks; and 553 tons dealt with by presses.

	£	s.	d.
Cost for each trip run by Steamer (or 1/6·6 per ton of Sludge).	77	11	5

FILTRATION.

	Gallons.	Gallons.
Septic Tank Effluent dealt with by Primary Beds (46 acres):—		
Quarter ending June 29th, 1927	2,094,350,000	
,, ,, September 28th, 1927	2,100,540,000	
,, ,, December 28th, 1927	2,132,920,000	
,, ,, March 28th, 1928	2,193,720,000	
		8,521,530,000
Unfiltered Tank Effluent:—		
Quarter ending June 29th, 1927	2,055,399,000	
,, ,, September 28th, 1927	2,618,909,000	
,, ,, December 28th, 1927	2,074,140,000	
,, ,, March 28th, 1928	3,223,435,000	
		9,971,883,000
Activated Sludge Tank (No. 12):—		
Quarter ending June 29th, 1927	20,091,000	
,, ,, September 28th, 1927	10,148,000	
,, ,, December 28th, 1927	52,372,000	
,, ,, March 28th, 1928	53,946,000	
		136,557,000
Total Sewage Flow:—		
Quarter ending June 29th, 1927	4,169,810,000	
,, ,, September 28th, 1927	4,729,597,000	18,629,970,000
,, ,, December 28th, 1927	4,259,432,000	
,, ,, March 28th, 1928	5,471,101,000	
Effluent from Primary Beds, dealt with by Secondary Beds:—		
Quarter ending June 29th, 1927	1,346,515,000	
,, ,, September 28th, 1927	1,466,815,000	
,, December 28th, 1927	1,470,789,000	
,, ,, March 28th, 1928	1,474,140,000	
		5,758,259,000

AVERAGE PER DAY.

	52 weeks ended March 28th, 1928	52 weeks ended March 30th, 1927	53 weeks ended March 31st, 1926
	Gallons.	Gallons.	Gallons.
Primary Beds	23,411,000	25,152,000	30,794,000
Storm Beds	...	...	3,846,000
Unfiltered Tank Effluent	27,395,000	22,648,000	13,904,000
Activated Sludge Tank ..	375,000	311,000	138,000
Total Sewage Flow	51,181,000	48,111,000	48,982,000
Secondary Beds	15,819,000	16,017,000	15,458,000

COST OF SEWAGE TREATMENT, 1927 1928.

		£ s. d.	£ s. d.
SCREENING:—			
Cleaning and Routine Work		1,516 13 0	
No. 1 Screen Maintenance		82 7 11	
No. 2 Screen Maintenance		49 8 4	
Wagon and Rail Maintenance		15 7 0	
Chamber Maintenance		87 17 7	
		1,751 13 10	
Less Sale of Screenings		14 1 6	
			1,737 12 4
SETTLEMENT TANKS:—			
Cleaning and Routine Operation		934 18 1	
Pumping off Supernatant Water		35 14 8	
Fabric Maintenance		15 6 2	
			985 18 11
SLUDGE EJECTORS:—			
Routine Operation		836 3 0	
No. 1 Ejector Maintenance		21 13 11	
No. 2 Ejector Maintenance		55 3 7	
Air Main Maintenance		2 9 1	
Reserve Ejectors Maintenance		48 10 4	
			963 19 11
SLUDGE STORAGE TANKS AND STEAMER LOADING:—			
Routine Cleaning and Operation		151 4 4	
Decanting Supernatant Water		25 18 5	
Tank Fabric Maintenance		13 10 1	
Loading Pipe Maintenance		28 1 5	
			218 14 3
SLUDGE BEDS:—			
Routine Operation		0 8 5	
Medium Surface Operations		113 17 3	
			114 5 8
SLUDGE DISPOSAL ON LAND:—			
Sludge Ploughing and Gripping		293 1 1	
Engine and Pump Operation		148 9 4	
Engine and Pump Maintenance		0 9 7	
Sludge Main and Distribution Pipe Maintenance		0 4 10	
Construction of Temporary Sludge Pumping Station		453 4 11	
			895 9 9
SLUDGE STEAMER:—			
Routine Running		8,144 6 7	
Canal Tolls, Insurances and Licenses		1,971 11 3	
Owners' Repairs and Renewals		2,631 8 7	
Repairs Recoverable from Underwriters		689 12 4	
		13,436 18 9	
Less Recovered from Underwriters		249 8 4	
			13,187 10 5
SLUDGE PRESSING:—			
Routine Work		102 16 6	
Plant Maintenance		7 15 3	
Building Maintenance		69 12 10	
			180 4 7
DRIED SEWAGE MANURE:—			
Routine Work		262 6 6	
Drier and Plant Maintainance		32 3 7	
Building Maintenance		44 2 10	
Agency Charges, Advertising etc.		82 14 10	
		421 7 9	
Less Sales of Dried Sewage Manure		346 2 3	
			75 5 6
			£18,359 1s. 4d.
GAUGING SEWAGE FLOW:—			
Routine Work		157 0 4	
Construction of Flow Recorder Cabin in Trafford Park		20 3 6	
			177 3 10
PRIMARY BEDS:			
Routine Operation		2,070 14 0	
Medium Surface Maintenance		3,338 11 3	
Fabric Maintenance		209 1 2	
	£ s. d.		
Medium Renewal	17,033 17 10		
Less Sale of Ashes	243 11 4		
		*16,790 6 6 (*See Foot Note)	
			22,408 12 11
SECONDARY BEDS:—			
Routine Operation		1,370 12 3	
Medium Surface Maintenance		2,858 17 11	
Fabric Maintenance		14 4 3	
			4,243 14 5
CARRIERS:—			
Routine Cleaning		15 0 9	
Fabric Maintenance		9 3 10	
			24 4 7
ACTIVATED SLUDGE PLANT:—			
Routine Operation		891 19 11	
Tank Fabric Maintenance		1 15 0	
Tank Equipment Maintenance		97 18 4	
Air Compressing Plant and House Maintenance		35 2 10	
Installation of New Compressor and Alterations to Air Main		440 11 8	
			1,467 7 9
GREASE RECOVERY:—			
Routine Work		246 17 10	
Construction of Storage Tank		36 19 5	
Dismantling Disused Grease Presses		8 12 5	
			292 9 8
ROAD REPAIRS:—			
Davyhulme Works		54 8 6	
Flixton Estate		35 8 8	
			89 17 2
FENCING:—			
Davyhulme Works		74 12 7	
Flixton Estate		5 17 3	
			80 9 10
RIVER BANK REPAIRS, FLIXTON			661 19 2
LAND CULTIVATION:—			
Routine Work		1,383 12 2	
Implement Maintenance		38 3 6	
Farm Building Maintenance (Flixton)		19 2 3	
			1,440 17 11
GARDENING			192 18 4
LABORATORY:—			
Routine Work		1,858 1 1	
Building Maintenance		0 10 8	
			1,858 11 9
DAVYHULME PARISH SEWAGE:—			
Screening and Pumping—Routine Operation		367 12 10	
Ejector Maintenance		8 15 1	
Air Main Maintenance		3 15 0	
Contact Beds—Medium Surface maintenance		23 6 6	
Contact Beds—Medium Renewal		3 7 8	
Alterations to Pumping Plant		72 4 7	
Contact Beds—Fabric Maintenance		16 3 0	
			495 4 8
WORKS ADMINISTRATION:—			
Routine Work		2,559 3 5	
Manager's Emoluments		70 16 2	
Administrative Building Maintenance		37 4 7	
Manager's Residence Maintenance		7 4 11	
			2,674 9 1
CONSULTING SERVICES *re* SEWAGE DISPOSAL			851 5 0
DEPUTATIONS AND COMMITTEE VISITS			111 0 2
VISITING DEPUTATIONS EXPENSES			27 18 9
MONETARY ALLOWANCES:—			
Sickness		87 4 3	
Workmen's Compensation		40 19 6	
Additional to Superannuation		60 8 0	
Compassionate (on Compulsory Retirement)		23 8 0	
			211 19 9
CARRIER BRIDGES, CONSTRUCTION			120 1 4
WORKS EXTENSIONS:—			
Technical and Advisory Services		169 18 2	
Temporary Draughtsmen and Engineering Office Sundries		130 9 6	
Alterations to No. 1 Washing Plant		167 8 9	
Sundry Work		121 7 0	
			589 3 5
RENTS, RATES, TAXES, AND INSURANCE:—			
Davyhulme Works		4,194 10 9	
Flixton Estate and Buildings		159 10 11	
Carrington Estate and Buildings		24 6 9	
Land along line of Sewer		3 8 0	
			4,381 16 5
WEED REMOVAL AND DISPOSAL			74 2 9
CLEANING DITCHES AND WATERCOURSES			66 15 9
PURCHASING AND PLANTING TREES ALONG NEW BOUNDARY			42 3 10
ERECTION OF STORES BUILDING ON FLIXTON ESTATE			22 8 10
SUNDRY UNCLASSIFIED ITEMS			40 13 1
			61,006 11 6
Less:—			
Sale of Sewage Grease		720 1 9	
Sale of Scrap Metal		304 9 3	
Sale of Sundry Materials		28 19 2	
Sale of Farm Produce		382 4 10	
Farm Produce consumed in Stables		149 13 0	
Rents of Farm Lands and Privileges		436 16 3	
			2,022 4 3
			£58,984 7 3

	£	s.	d.
Average cost per million gallons	3	3	3·9
Average cost per million gallons for year ended 30th March, 1927	3	5	7·2
Average cost per head of population connected to sewers	0	1	6·6
Average cost per head of population connected to sewers for year ended 30th March, 1927	0	1	6·2

In comparing these costs with the charge on the rates (see page 5) sums of £2,458 7s. 0d. (expended out of Bacteria Beds Renewal Account) and £581 12s. 6d. (interest on Bacteria Beds Renewal Fund) must be deducted; and £367 2s. 2d. (posted to Depreciation Account), £114 19s. 11d. (materials manufactured or produced on works and taken on Stores Account), £307 5s. 10d. (recoverable from other works), and £12 18s. 0d. (overlapping accounts) must be added.

NOTE A Contribution of £11,597 16s. 11d. from the Local Authorities of Stretford, Middleton, Audenshaw, and Barton is not included in the above Statement.

*

WASHING.

Quantity.	Tons.
Fouled Medium Washed	31,927
Fouled Medium Rewashed	5,864
Storm Bed Medium Washed or Riddled ..	6,580
	47,371

Cost.	£ s. d.
No. 1 Washer	3,174 11 5
No. 2 Washer	3,295 9 5
Removing Refuse from Washers	661 9 1
Refuse Tip	778 10 7
Loading and Delivering Ashes Sold	131 10 4
	8,041 10 10
Less Ashes Sold	243 11 4
	£7,797 19 6

Cost per ton =3s. 3·5d.

SUMMARY.

	£ s. d.
Emptying Beds	2,484 3 2
Filling Beds	1,125 12 7
Washing Ashes	7,797 19 6
Hauling to and from Beds	2,642 16 10
Hauling to Crusher, Crushing, and returning to Washer	1,938 6 2
Purchase of New Medium	801 8 3
	£16,790 6 6

Table V.

SUMMARY OF STATISTICS.

DAVYHULME SEWAGE WORKS.

SLUDGE DISPOSAL BY STEAMER—		
Cost per trip		£77 11 5
Cost per ton of sludge		0 1 6·6
SLUDGE DISPOSAL, AVERAGE COST PER TON		0 1 9·7
RAIL TRANSPORT—		
Cost per locomotive per operative hour		0 5 6·7
Coal consumed	tons	518·7
Average price of coal per ton		£1 4 2
HORSE TRANSPORT—		
"All-in" cost per horse per working hour		0 1 4·7
Cost of keep per horse per week		0 16 1·1
MOTOR TRANSPORT (30-cwt. "Morris")—		
Cost per operative hour		0 1 10·4
Miles run		10,532
Average mileage per week		206·6
Petrol consumption	gallons	812·5
Miles run per gallon of petrol		12·9
Net cost per mile run		£0 0 4·9
STEAM SHOVEL—Cost per operative hour		0 5 6·8
CRUSHER—Cost per operative hour		0 1 7·8
WORKSHOP EXPENSES (Cost per hour)—		
Fitting Shop		0 0 4·1
*Blacksmith's Shop		0 1 11·6
Joiner's Shop		0 0 1·4
Painter's Shop		0 0 0·8

* Including manufacture and repair of tools and cost of compressed air for hearths.

DAVYHULME WORKS.

TABLE VI.—COMPARATIVE ANNUAL COSTS, ETC., PERIOD 1924–25 to 1927–28.

Year	Total			Sludge produced	Trips run by steamer	Refuse from screens	Sewage flow	Cost per million gallons			Average population connected to sewers.	Cost per head		
	£	s.	d.	Tons		Tons	Gallons	£	s.	d.		£	s.	d.
1924–25	52,771	9	8	245,684	220	4,291	20,524,654,000	2	11	5·1	750,500	0	1	4·9
1925–26	57,268	17	7	236,101	199	4,925	18,172,380,000	3	3	0·4	754,000	0	1	6·2
1926–27	57,442	13	6	221,546	181	5,085	17,512,465,000	3	5	7·2	757,000	0	1	6·2
1927–28	58,984	7	3	197,792	170	5,042	18,629,970,000	3	3	3·9	760,200	0	1	6·6

DAVYHULME WORKS.

Table VII.

TABLE VII—SHOWING THE CHEMICAL COMPOSITION OF THE RAW SEWAGE (AVERAGE OF HOURLY SAMPLES) AND OF THE UNFILTERED TANK EFFLUENT, TOGETHER WITH THE RELATIVE VOLUMES OF EACH.

DATE	4 Hours oxygen absorption			Free and saline ammonia			Albuminoid ammonia			Nitrite (in terms of NH_3)	Nitrate (in terms of NH_3)	Chloride (in terms of Cl.)			INCUBATION TEST					TOTAL QUANTITY Gallons			Percentage of total flow dealt with on the filtration areas and by the activated sludge process
															3 Minutes oxygen absorption				Putrescibility				
															Before incubation			After incubation					
Quarter ending	Manchester raw sewage	Davyhulme Parish sewage	Tank effluent	Manchester raw sewage	Davyhulme Parish sewage	Tank effluent	Manchester raw sewage	Davyhulme Parish sewage	Tank effluent	Tank effluent	Tank effluent	Manchester raw sewage	Davyhulme Parish sewage	Tank effluent	Manchester raw sewage	Davyhulme Parish sewage	Tank effluent	Tank effluent	Tank effluent	Total raw sewage	Davyhulme Parish sewage	Tank effluent (Unfiltered)	
1927																							
June 29th	8·26	3·38	6·43	2·50	2·30	2·70	·61	·49	·495	·01	·09	13·2	4·0	13·3	3·52	1·27	2·82	4·34	56½/57	4,169,840,000	5,119,000	2,055,399,000	50·7
September 28th	6·56	3·35	5·75	1 95	1·90	2·07	·55	·48	·495	Trace	·09	11·9	4·1	11·2	3·05	1·36	2·74	4·24	64/64	4,729,597,000	7,807,000	2,618,909,000	44·6
December 28th	7·16	3·46	6·34	2·01	2·27	2·14	·595	·57	·47	·01	·13	13·9	4·3	13·4	3·37	1·29	3·00	3·87	60/63	4,259,432,000	9,341,000	2,074,140,000	51·3
1928																							
March 28th	6·81	1·78	5·66	1·60	1·25	1·54	·455	·285	·35	·015	·22	12·1	3·3	11·1	3·08	·63	2·61	3·16	56½/63	5,471,101,000	8,218,000	3,223,435,000	41·1
Average	7·20	2·99	6·05	2·02	1·93	2·11	·55	·455	·45	·01	·13	12·8	3·9	12·3	3·26	1·14	2·79	3·90	237/247	18,629,970,000	30,485,000	9,971,883,000	46·5
Average for year ending March 30th, 1927 ...	7·50	3·03	5·96	2·14	1·76	2·16	·62	·44	·475	·01	·10	12·6	4·2	11·7	3·41	1.15	2·74	3·87	248½/250	17,512,465,000	20,452,000	8,243,755,000	52·9

DAVYHULME WORKS.

PRIMARY BEDS.—SERIES I., II., III., AND IIIA.

TABLE VIII.—SHOWING QUANTITY DEALT WITH, AND CHEMICAL COMPOSITION OF FILTRATE OBTAINED.

DATE	4 Hours oxygen absorption						Free and saline ammonia						Albuminoid ammonia						Nitrite (in terms of NH_3)			Nitrate (in terms of NH_3)		
																			Series			Series		
Quarter ending	Raw sewage	Tank effluent	Series I.	Series II.	Tank effluent	Series III. and IIIa.	Raw sewage	Tank effluent	Series I.	Series II.	Tank effluent	Series III. and IIIa.	Raw sewage	Tank effluent	Series I.	Series II.	Tank effluent	Series III. and IIIa.	I.	II.	III. and IIIa.	I.	II.	III. and IIIa.
1927 June 29th	8·26	8·08	4·19	3·81	6·94	3·18	2·50	2·66	2·13	2·30	2·75	2·17	·61	·52	·31	·29	·515	·275	·01	·015	·01	·09	·13	·11
September 28th..................	6·56	6·70	3·40	2·75	5·38	2·33	1·95	2·11	1·75	1·83	2·43	1·98	·55	·465	·26	·225	·44	·23	·01	·01	·015	·10	·11	·12
December 28th	7·16	6·36	3·15	2·94	6·00	2·36	2·01	1·94	1·52	1·50	2·53	1·98	·595	·39	·21	·19	·43	·19	·02	·01	·025	·15	·15	·18
1928 March 28th	6·81	5·96	3·20	2·83	5·02	2·24	1·60	1·62	1·39	1·38	1·71	1·51	·455	·36	·205	·185	·335	·17	·015	·015	·015	·24	·25	·26
Average	7·20	6·78	3·49	3·08	5·84	2·53	2·02	2·08	1·70	1·75	2·36	1·91	·55	·435	·245	·22	·43	·215	·015	·01	·015	·15	·16	·17
Average for year ending March 30th, 1927 ...	7·50	6·56	3·68	3·42	5·83	2·72	2·14	2·19	1·88	1·97	2·45	2·03	·62	·42	·245	·235	·45	·245	·015	01	·01	·08	·09	·11
Purification effected Calculated on tank effluent			49%	55%		57%									44%	49%		50%						
Corresponding purification for year ending March 30th, 1927			44%	48%		53%									42%	44%		46%						
Calculated on raw sewage			52%	57%		65%									55%	60%		61%						
Corresponding purification for year ending March 30th, 1927			51%	54%		64%									60%	62%		60%						

DATE	Chloride (in terms of Cl)						INCUBATION TEST												Quantity dealt with (Gallons)			Average quantity dealt with					
							3 Minutes oxygen absorption									Putrescibility						Per acre per day (Gallons)			Per cubic yard per day (Gallons)		
							Before incubation						After incubation														
													Series			Series			Series			Series			Series		
Quarter ending	Raw sewage	Tank effluent	Series I.	Series II.	Tank effluent	Series III. and IIIa.	Raw sewage	Tank effluent	Series I.	Series II.	Tank effluent	Series III. and IIIa.	I.	II.	III. and IIIa.	I.	II.	III. and IIIa.	I.	II.	III. and IIIa.	I.	II.	III. and IIIa.	I.	II.	III. and IIIa.
1927 June 29th	13·2	14·4	13·1	13·1	11·8	10·9	3·52	3·76	2·08	1·94	3·23	1·58	2·88	2·51	2·10	12/12	10½/12	13/13	862,460,000	244,700,000	987,190,000	474,000	448,000	512,000	83	83	100
September 28th..................	11·9	12·8	11·7	12·0	10·1	9·4	3·05	3·34	1·78	1·39	2·67	1·18	2·58	1·95	1·67	12/13	13/13	10½/13	970,350,000	338,300,000	791,8[illegible]0,000	533.000	620,000	435,000	99	115	81
December 28th	13·9	15·2	13·7	13·4	12·1	10·5	3·37	3·33	1·71	1·55	2·99	1·27	2·03	1·88	1·44	10/13	11/13	9½/13	1,000,540,000	288,500,000	843,880,000	550,000	528,000	464,000	102	98	86
1928 March 28th	12·1	12·0	11·0	11·1	10·6	9·3	3·08	2·86	1·67	1·46	2·52	1·20	2·07	1·75	1·29	9½/13	8/13	6/13	1,132,680,000	199,000,000	862,040,000	622,000	364,000	474,000	115	67	88
Average	12·8	13·6	12·4	12·4	11·2	10·0	3·26	3·32	1·81	1·59	2·85	1·31	2·39	2·02	1·63	43½/51	42½/51	39/52	3,966,030,000	1,070,500,000	3,485,000,000	545,000	490,000	479,000	101	91	89
Average for year ending March 30th, 1927 ...	12·6	13·7	12·5	12·6	11·0	9·9	3·41	3·17	1·97	1·81	2·86	1·40	2·56	2·40	1·91	45/50	46/50	47/52	3,808,800,000	1,445,800,000	3,900,690,000	523,000	662,000	536,000	97	123	99

DAVYHULME WORKS

HALF ACRE SECOND CONTACT BED—No. 10A.

TABLE IX.—SHOWING QUANTITY DEALT WITH AND CHEMICAL COMPOSITION OF FILTRATE OBTAINED.

Date	4 Hours oxygen absorption		Free and saline ammonia		Albuminoid ammonia		Nitrite (in terms of NH_3)		Nitrate (in terms of NH_3)		Chloride (in terms of Cl.)		Incubation test						Total quantity dealt with	Average quantity dealt with	
													3 Minutes oxygen absorption				Putrescibility			Per day	Per cubic yard per day
													Before incubation		After incubation						
Quarter ending	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Gallons	Gallons	Gallons
1927 June 29th	4·27	1·36	2·12	1·12	·35	·13	·015	·02	·10	·78	11·3	11·1	2·05	·60	2·96	·61	10/12	0/10	13,680,000	150,000	75
September 28th	4·19	1·35	1·86	1·06	·33	·13	Trace	·03	·09	·61	11·5	11·1	2·21	·62	3·11	·56	11½/12	0/9	12,312,000	135,000	68
December 28th	4·02	1·33	1·92	·94	·275	·115	·015	·02	·13	·91	12·7	11·7	2·11	·63	2·70	·50	8½/12	0/8	10,944,000	120,000	60
1928 March 28th	3·72	1·25	1·49	·79	·22	·095	·015	·01	·19	·81	11·9	10·4	1·99	·59	2·33	·50	9/13	0/10	13,680,000	150,000	75
Average	4·05	1·32	1·85	·98	·295	·115	·015	·02	·13	·78	11·9	11·1	2·09	·61	2·78	·54	39/49	0/37	50,616,000	139,000	70
Average for year ending March 30th, 1927	3·80	1·38	1·88	1·04	·28	·12	·01	·02	·08	·77	11·4	10·9	2·01	·65	2·66	·53	44/52	0/39	53,124,000	146,000	73
Purification effected Calculated on primary effluent		67%				61%															
Corresponding purification for year ending March 30th, 1927		64%				57%															
Calculated on raw sewage		82%				79%															
Corresponding purification for year ending March 30th, 1927		82%				81%															

Table X.

DAVYHULME WORKS.

No. 1 SECONDARY BED

TABLE X.—SHOWING QUANTITY DEALT WITH AND CHEMICAL COMPOSITION OF FILTRATE OBTAINED.

Date	4 Hours oxygen absorption		Free and saline ammonia		Albuminoid ammonia		Nitrite (in terms of NH_3)		Nitrate (in terms of NH_3)		Chloride (in terms of Cl.)		Incubation test						Total quantity dealt with	Average quantity dealt with	
													3 Minutes oxygen absorption				Putrescibility			Per day	Per cubic yard per day
													Before incubation		After incubation						
Quarter ending	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Gallons	Gallons	Gallons
June 29th, 1927 ……	4·13	1·81	2·23	1·51	·345	·185	·01	·025	·07	·50	11·2	12·1	2·07	·87	3·00	·87	21½/24	4/24	56,160,000	617,000	96
September 28th, 1927	3·75	1·46	1·94	1·13	·315	·15	Trace	·03	·08	·51	11·2	11·2	1·91	·72	3·11	·58	23/25	0/25	56,160,000	617,000	96
December 28th, 1927	3·97	1·63	1·93	1·11	·27	·135	Trace	·025	·10	·65	12·3	12·8	2·02	·80	2·76	·77	22/25	2½/25	56,160,000	617,000	96
March 28th, 1928 …	3·38	1·62	1·54	·97	·225	·115	·015	·015	·19	·56	10·6	11·5	1·74	·80	2·12	·74	17½/26	1/23	50,400,000	554,000	87
Average ……………	3·81	1·63	1·91	1·18	·29	·145	·01	·025	·11	·56	11·3	11·9	1·94	·80	2·75	·74	84/100	7½/97	218,880,000	601,000	94
Average for year ending March 30th, 1927	3·63	1·75	2·05	1·33	·29	·16	·01	·02	·08	·48	11·3	11·7	1·93	·87	2·73	·86	95/103	14½/94	208,080,000	572,000	89
Purification effected. Calculated on primary effluent		57%				50%															
Purification effected. Corresponding purification for year ending March 30th, 1927		52%				45%															
Purification effected. Calculated on raw sewage		77%				74%															
Purification effected. Corresponding purification for year ending March 30th, 1927		77%				74%															

DAVYHULME WORKS.

Table XI.

SECOND CONTACT BEDS—Nos. 5 to 19 (inclusive).

TABLE XI.—SHOWING QUANTITIES DEALT WITH AND CHEMICAL COMPOSITION OF FILTRATE.

DATE	4 Hours oxygen absorption		Free and saline ammonia		Albuminoid ammonia		Nitrite (in terms of NH_3)		Nitrate (in terms of NH_3)		Chloride (in terms of Cl.)		Incubation test						Quantity dealt with	Average quantity dealt with	
													3 Minutes oxygen absorption				Putrescibility			Per day	Per cubic yard per day
													Before incubation		After incubation						
Quarter ending	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Gallons	Gallons	Gallons
June 29th, 1927 ...	4·13	1·40	2·23	1·22	·345	·14	·01	·025	·07	·64	11·2	11·9	2·07	·63	3·00	·62	21½/24	0/24	497,160,000	5,463,000	90
September 28th, 1927	3·75	1·51	1·94	1·19	·315	·15	Trace	·025	·08	·43	11·2	11·0	1·91	·70	3·11	·72	23/25	2½/25	450,759,000	4,953,000	82
December 28th, 1927	3·97	1·64	1·93	1·11	·27	·135	Trace	·025	·10	·64	12·3	12·3	2·02	·78	2·76	·77	22/25	1½/25	448,263,000	4,926,000	81
March 28th, 1928 ...	3·38	1·38	1·54	·89	·225	·11	·015	·01	·19	·65	10·6	10·6	1·74	·64	2·12	·56	17½/26	0/26	490,122,000	5,386,000	89
Average	3·81	1·48	1·91	1·10	·29	·135	·01	·02	·11	·59	11·3	11·5	1·94	·69	2·75	·67	84/100	4/100	1,886,304,000	5,182,000	86
Average for year ending Mar. 30th, 1927	3·63	1·58	2·05	1·21	·29	·145	·01	·02	·08	·53	11·3	11·3	1·93	·76	2·73	·75	95/103	9½/103	1,899,150,000	5,217,000	86
Purification effected Calculated on primary effluent		61%				53%															
Corresponding purification for year ending March 30th, 1927		56%				50%															
Calculated on raw sewage		79%				75%															
Corresponding purification for year ending March 30th, 1927		79%				77%															

SECOND CONTACT BEDS—Nos. 2 and 20 to 27 (inclusive).

TABLE XII.—SHOWING QUANTITIES DEALT WITH AND CHEMICAL COMPOSITION OF FILTRATE OBTAINED.

DATE	4 Hours oxygen absorption		Free and saline ammonia		Albuminoid ammonia		Nitrite (in terms of NH$_3$)		Nitrate (in terms of NH$_3$)		Chloride (in terms of Cl.)		INCUBATION TEST						QUANTITY DEALT WITH	AVERAGE QUANTITY DEALT WITH	
													3 Minutes oxygen absorption				Putrescibility			Per day	Per cubic yard per day
													Before incubation		After incubation						
Quarter ending	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Gallons	Gallons	Gallons
June 29th, 1927 ……	4·13	1·59	2·23	1·27	·345	·155	·01	·03	·07	·63	11·2	12·1	2·07	·73	3·00	·70	21½/24	2/24	197,399,000	2,169,000	66
September 28th, 1927	3·75	1·38	1·94	1·03	·315	·14	Trace	·025	·08	·53	11·2	11·3	1·91	·65	3·11	·60	23/25	½/25	220,864,000	2,427,000	74
December 28th, 1927	3·97	1·46	1·93	·97	·27	·125	Trace	·02	·10	·71	12·3	12·8	2·02	·71	2·76	·66	22/25	1/25	217,332,000	2,388,000	72
March 28th, 1928 …	3·38	1·42	1·54	·82	·225	·11	·015	·015	·19	·61	10·6	11·0	1·74	·70	2·12	·62	17½/26	1½/26	202,906,000	2,230,000	68
Average …………	3·81	1·46	1·91	1·02	·29	·13	·01	·02	·11	·62	11·3	11·8	1·94	·70	2·75	·65	84/100	5/100	838,501,000	2,304,000	70
Average for year ending March 30th, 1927 …	3·63	1·53	2·05	1·13	·29	·14	·01	·02	·08	·56	11·3	11·6	1·93	·75	2·73	·67	95/103	4½/103	849,651,000	2,334,000	71
Purification effected: Calculated on primary effluent		62%				55%															
Purification effected: Corresponding purification for year ending March 30th, 1927		58%				52%															
Purification effected: Calculated on raw sewage		80%				76%															
Purification effected: Corresponding purification for year ending March 30th, 1927		80%				77%															

DAVYHULME WORKS.

SECOND CONTACT BEDS—Nos. 32 to 35.

Table XIII.

TABLE XIII.—SHOWING QUANTITY DEALT WITH AND CHEMICAL COMPOSITION OF FILTRATE.

DATE	4 Hours oxygen absorption		Free and saline ammonia		Albuminoid ammonia		Nitrite (in terms of NH_3)		Nitrate (in terms of NH_3)		Chloride (in terms of Cl.)		Incubation test						Quantity dealt with	Average quantity dealt with	
													3 Minutes oxygen absorption				Putrescibility			Per day	Per cubic yard per day
													Before incubation		After incubation						
Quarter ending	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Gallons	Gallons	Gallons
June 29th, 1927	4·27	1·34	2·12	·88	·35	·125	·015	·025	·10	·81	11·3	11·1	2·05	·59	2·96	·55	10/12	0/8	141,780,000	1,558,000	63
September 28th, 1927	4·19	1·22	1·86	·76	·33	·115	Trace	·025	·09	·67	11·5	10·4	2·21	·57	3·11	·52	11½/12	0/12	234,600,000	2,578,000	105
December 28th, 1927	4·02	1·32	1·92	·80	·275	·115	·015	·02	·13	·85	12·7	11·5	2·11	·63	2·70	·56	8½/12	0/12	238,680,000	2,623,000	107
March 28th, 1928 ...	3·72	1·39	1·49	·68	·22	·09	·015	·01	·19	·87	11·9	10·4	1·99	·66	2·33	·55	9/13	0/13	238,680,000	2,623,000	107
Average	4·05	1·32	1·85	·78	·295	·11	·015	·02	·13	·80	11·9	10·9	2·09	·61	2·78	·55	39/49	0/45	853,740,000	2,345,000	95
Average for year ending March 30th, 1927 ...	3·80	1·46	1·88	·92	·28	·12	·01	·02	·08	·77	11·4	10·8	2·01	·70	2·66	·60	44/52	1/48	890,040,000	2,445,000	99
Purification effected Calculated on primary effluent		67%				63%															
Corresponding purification for year ending March 30th, 1927.		62%				57%															
Calculated on raw sewage		82%				80%															
Corresponding purification for year ending March 30th, 1927.		81%				81%															

DAVYHULME WORKS.

SECOND CONTACT BEDS—Nos. 36–39 (INCLUSIVE).

TABLE XIV.—SHOWING QUANTITY DEALT WITH AND CHEMICAL COMPOSITION OF FILTRATE.

DATE		4 Hours oxygen absorption		Free and saline ammonia		Albuminoid ammonia		Nitrite (in terms of NH_3)		Nitrate (in terms of NH_3)		Chloride (in terms of Cl.)		Incubation test						Quantity dealt with	Average quantity dealt with	
														3 Minutes oxygen absorption				Putrescibility			Per day	Per cubic yard per day
														Before incubation		After incubation						
Quarter ending		Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Primary effluent	Secondary effluent	Gallons	Gallons	Gallons
June 29th, 1927......		4·27	1·49	2·12	·92	·35	·135	·015	·02	·10	·87	11·3	11·9	2·05	·66	2·96	·61	10/12	0/10	181,560,000	1,995,000	88
September 28th, 1927		4·19	1·21	1·86	·72	·33	·115	Trace	·025	·09	·75	11·5	10·4	2·21	·56	3·11	·51	11½/12	0/12	235,620,000	2,589,000	114
December 28th, 1927		4·02	1·29	1·92	·76	·275	·115	·015	·015	·13	·88	12·7	11·5	2·11	·63	2·70	·51	8½/12	0/12	238,680,000	2,623,000	116
March 28th, 1928 ...		3·72	1·57	1·49	·78	·22	·11	·015	·01	·19	·79	11·9	10·5	1·99	·78	2·33	·63	9/13	0/13	238,680,000	2,623,000	116
Average		4·05	1·39	1·85	·80	·295	·12	·015	·02	·13	·82	11·9	11·1	2·09	·66	2·78	·57	39/49	0/47	894,540,000	2,457,000	108
Average for year ending March 30th, 1927 ...		3·80	1·47	1·88	·87	·28	·12	·01	·02	·08	·81	11·4	10·8	2·01	·70	2·66	·60	44/52	1/49	943,500,000	2,592,000	114
Purification effected	Calculated on primary effluent		66 %				59 %															
	Corresponding purification for year ending March 30th, 1927		61 %				57 %															
	Calculated on raw sewage		81 %				78 %															
	Corresponding purification for year ending March 30th, 1927		80 %				81 %															

DAVYHULME WORKS.

TABLE XV.—SHOWING THE AMOUNT OF SUSPENDED SOLIDS CONTAINED IN THE SEWAGE, TANK EFFLUENTS, AND FILTRATES.

	RESULTS EXPRESSED IN GRAINS PER GALLON								
	Average for the year ending March 28th, 1928			Average for the year ending March 30th, 1927			Average for the year ending March 31st, 1926		
	Mineral	Organic and Volatile	Total	Mineral	Organic and Volatile	Total	Mineral	Organic and Volatile	Total
Sewage	7·6	11·4	19·0	8·0	12·5	20·5	8·7	13·8	22·5
Open Septic Tank Effluent (East)	4·2	5·5	9·7	2·6	3·9	6·5	3·4	5·2	8·6
Series I. (Beds 13 to 52)	2·3	3·1	5·4	1·5	2·5	4·0	2·1	3·4	5·5
Do. II. (Beds 1A to 10)	2·6	3·4	6 0	2·2	3·0	5·2	2·6	3·6	6·2
Open Septic Tank Effluent (West)	3·8	5·1	8·9	2·6	4·2	6·8	3·0	5·0	8 0
Series III. and IIIA (Beds 53 to 92)	1·9	2·6	4·5	1·7	2·4	4·1	1·6	2·8	4·4
Unfiltered Tank Effluent	4·4	6·2	10·6	4·0	6·0	10·0	4·8	7·9	12·7
Second Contact Bed (No. 10A)	1·1	1·2	2·3	·7	1·0	1·7	·9	1·4	2·3
Do. do. (No. 1)	1·2	1 3	2·5	·7	1·0	1·7	·9	1·4	2·3
Do. do. (Nos. 2 to 27 inclusive) ...	1·3	1·3	2·6	·7	1·0	1·7	1·1	1·5	2·6
Do. do. (Nos. 32 to 39 inclusive) ...	1 3	1·3	2·6	·9	1·0	1·9	·9	1·2	2·1

Table XV.

DAVYHULME WORKS.

TABLE XVI.—RESULTS OF EXAMINATION OF THE SHIP CANAL WATER ABOVE AND BELOW THE OUTFALL.

DATE	Four hours oxygen absorption		Free and saline ammonia		Albuminoid ammonia		Chloride (in terms of Cl.)		Incubation Test						Percentage rise in the 3 minutes oxygen absorption test after incubation	
									3 Minutes oxygen absorption				Putrescibility			
									Before incubation		After incubation					
Month	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
April 1927	·73	1·15	·27	·43	·065	·105	4·0	4·8	·29	·52	·24	·54	0/7	1/7	—	—
May ,,	1·19	1·53	·69	·91	·13	·175	7·2	8·2	·52	·74	·81	1·11	6/10	8/10	—	—
June ,,	1·27	1·35	·98	1·09	·135	·16	8·1	8·2	·50	·54	·84	·89	3/4	3/4	—	—
July ,,	1·07	1·53	·54	·76	·12	·15	7·0	7·8	·45	·72	·68	1·06	1/2	2/2	—	—
August ,,	·74	·99	32	·41	·095	·105	3·7	4·2	·29	·43	·34	·59	1½/10	3½/10	—	—
September ,,	·62	·87	·21	·31	·055	·075	3·4	4·0	·27	·42	·29	·47	0/5	1/5	—	—
October ,,	·75	1·02	·25	·35	·06	·075	4·4	5·1	·32	·46	·43	·57	1½/8	2/8	—	—
November ,,	·63	·88	·19	·29	·055	·065	3·8	4·8	·25	·37	·27	·42	0/8	0/8	—	—
December ,,	1·04	1·40	·52	·71	·11	·15	6·3	7·1	·46	66	·56	·82	1½/5	3/5	—	—
January 1928	·51	·85	·17	·20	·05	·065	2·5	3·4	·18	·34	·19	·29	0/8	0/8	—	—
February ,,	·57	·94	·21	·29	·055	·07	2·9	3·8	·24	·39	·27	·41	½/4	½/4	—	—
March ,,	1·19	1·65	·45	·61	·105	·14	6·1	7·0	·51	·77	·73	1·17	8/9	7½/9	—	—
Average	·86	1·18	·40	·53	·085	·11	5·0	5·7	·36	·53	·47	·70	23/80	31½/80	31%	32%
Average for year ending:— March, 1927	·93	1·21	·48	·60	·095	·12	5·5	6·3	·37	·53	·50	·73	24/81	35½/81	35%	38%
March, 1926	1·03	1·25	·56	67	·11	·125	5 8	6·5	·45	·57	·61	·83	32½/85	38/85	36%	46%
,, 1925	·93	1·12	·44	·53	·11	·12	4·7	5·4	·39	·51	·57	·68	38/95	40/95	46%	33%
,, 1924	1·03	1·17	·56	·66	·135	·145	5·3	6·5	·44	·53	·59	·66	22½/86	20/86	34%	25%
,, 1923	1·11	1·26	·58	·69	·145	·16	5·4	6·6	·50	·58	·59	·66	26½/83	25/83	18%	14%
,, 1922	1·09	1·33	·66	·82	·135	·16	5·6	6·8	·49	·61	·63	·80	32/81	41/81	29%	31%
,, 1921	1·01	1·19	·51	·66	·13	·15	5·4	6·3	·46	·56	·54	·64	21½/76	25/76	17%	14%
,, 1920	1·19	1·42	·60	·74	·125	·145	5·9	7·1	·54	·67	·77	·95	40/76	40/76	43%	42%

A=Sample taken above the outlet of effluent from the works. **B**=Sample taken below the outlet of effluent from the works.

TABLE XVII.—PARTICULARS *RE* COST FOR SEWAGE DISPOSAL OF THE CITY OF MANCHESTER AT THE DAVYHULME WORKS, 1896 to 1927.

Year ending	Maintenance charge		Capital charge		Total outlay on purification works to date	Total capital and maintenance charges		Per cent. purification of raw sewage		Average number of population connected to sewers
	Total per annum	Cost per head of population	Total per annum	Cost per head of population		Total per annum	Cost per head of population	As measured by the 4 hours oxygen absorption test	As measured by the albuminoid ammonia test	
	£	Pence	£	Pence	£	£	Pence	Per cent.	Per cent.	
December, 1896	15,780	10·4	8,129	5·4	162,572	23,909	15·8	......	......	363,040
,, 1897	19,089	9·9	9,797	5·1	195,942	28,886	15·0	......	......	462,020
,, 1898	20,000	9·3	10,517	4·9	210,334	30,517	14·2	......	......	515,120
March, 1900	18,728	8·1	10,634	4·6	212,672	29,362	12·7	......	......	553,910
,, 1901	21,439	9·2	10,793	4·6	215,866	32,232	13·8	39	38	558,812
,, 1902	19,212	8·2	12,395	5·3	247,893	31,607	13·5	40	40	564,200
,, 1903	15,512	6·6	17,473	7·4	349,457	32,985	14·0	38	41	567,570
,, 1904	14,684	6·1	21,316	8·7	426,323	36,000	15·0	45	52	574,130
,, 1905	14,273	6·0	23,506	9·8	470,121	37,779	15·8	68	71	575,270
,, 1906	18,648	7·8	24,069	10·0	481,374	42,717	17·8	70	74	575,900
,, 1907	21,795	9·1	24,029	10·0	480,566	45,824	19·1	64	69	576,620
,, 1908	27,147	11·3	24,730	10·3	494,614	51,877	21·6	61	68	577,230
,, 1909	30,457	12·4	25,982	10·6	519,643	56,439	23·0	64	70	588,600
,, 1910	27,674	11·0	27,239	10·8	544,785	54,913	21·8	67	72	603,910
,, 1911	22,660	8·9	28,444	11·2	568,884	51,104	20·1	69	70	611,100
,, 1912	24,530	9·8	29,569	11·8	591,376	54,099	21·6	74	76	602,000*
,, 1913	28,730	11·4	29,928	11·9	598,567	58,658	23·3	74	76	605,000
,, 1914	31,634	12·3	30,540	11·9	610,794	62,174	24·2	77	78	616,000
,, 1915 (53 weeks)	32,347	11·4	30,832	10·8	616,637	63,179	22·2	71	71	682,000
,, 1916	30,871	9·8	30,857	9·8	617,149	61,728	19·6	71	72	755,000
,, 1917	26,818	8·5	31,121	9·9	622,425	57,939	18·4	68	71	755,000
,, 1918	30,798	9·6	31,121	9·7	622,425	61,919	19·3	62	63	768,000
,, 1919	34,954	11·0	31,121	9·8	622,425	66,075	20·8	58	61	764,000
,, 1920 (53 weeks)	61,805	19·4	31,683	9·9	633,676	93,488	29·3	54	60	765,000
,, 1921	92,595	28·8	31,840	9·9	636,805	124,435	38·7	51	55	770,500
,, 1922	97,298	31·5	32,088	10·3	641,764	129,386	41·9	54	59	741,600*
,, 1923	73,759	23·7	32,278	10·4	645,568	106,037	34·1	62	63	747,100
,, 1924	68,382	21·9	32,278	10·4	645,568	100,660	32·3	63	65	748,300
,, 1925	52,771	16·9	32,278	10·3	645,568	85,049	27·2	53	57	750,500
,, 1926 (53 weeks)	57,269	18·2	32,278	10·3	645,568	89,547	28·5	54	56	754,000
,, 1927	57,442	18·2	33,322	10·6	666,443	90,764	28·8	49	51	757,000
,, 1928	58,984	18·6	35,582	11·2	711,645	94,566	29·8	45	45	760,200

NOTE.—The capital charges given above include the cost of all land purchases at Davyhulme and Flixton.

The annual charges have been computed by taking 5 per cent. of the total outlay to date.

* The estimation of the population connected to the sewers was revised in the light of the latest census returns.

SHIP CANAL WATER ABOVE WORKS OUTFALL.

DIAGRAM 1.

INCUBATOR TEST.

3 MINUTES OXYGEN ABSORPTION.

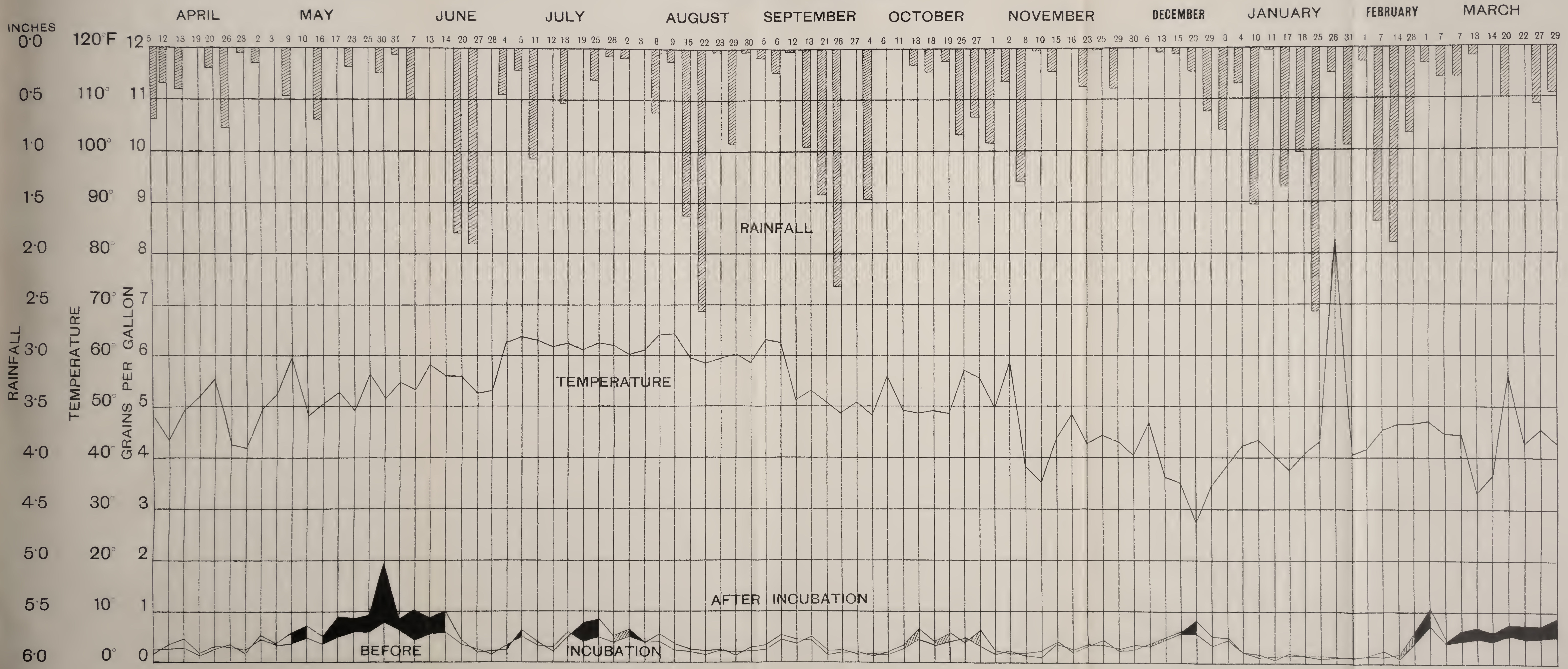
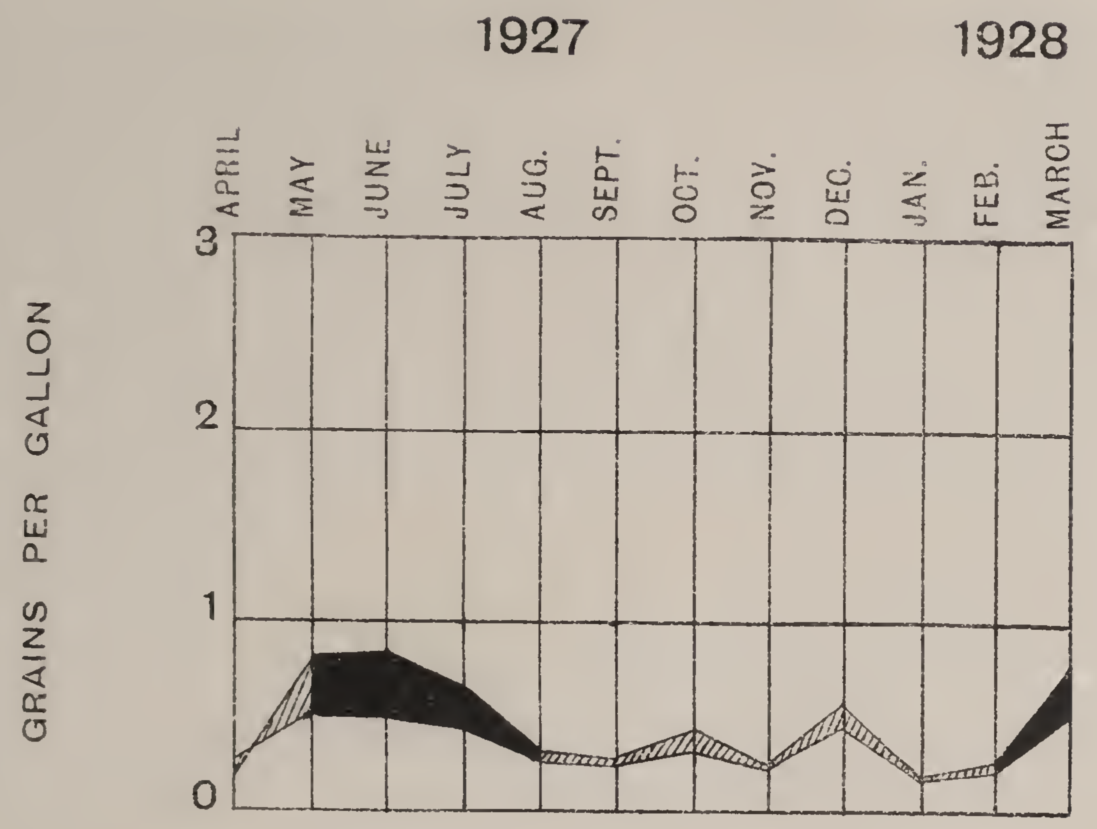


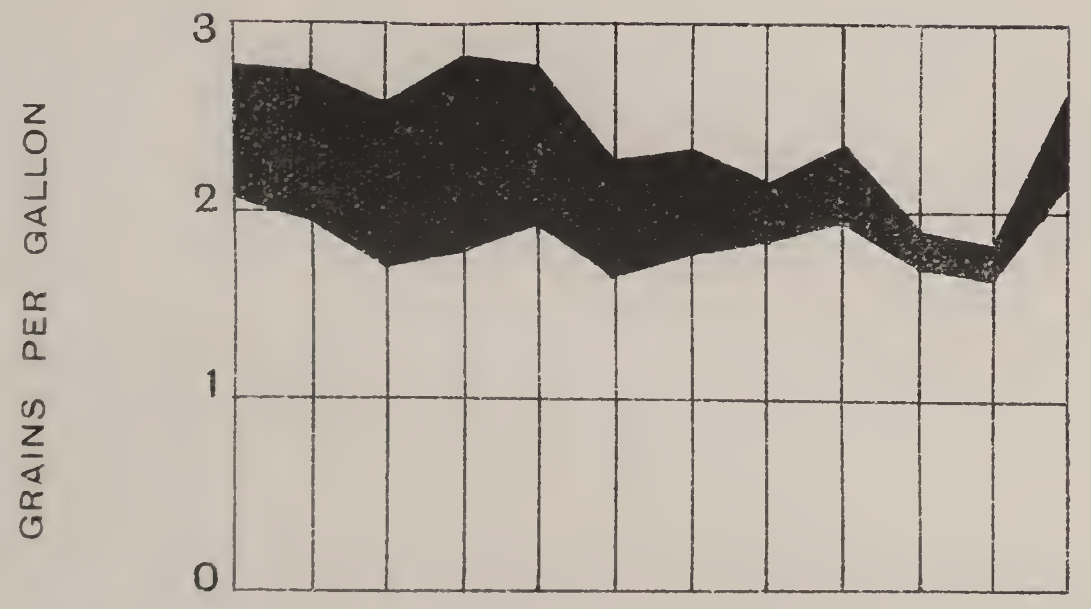
DIAGRAM 2.

MONTHLY AVERAGES OF ANALYSES OF SHIP CANAL WATER TAKEN ABOVE AND BELOW WORKS OUTFALL, AND AVERAGE EFFLUENT FROM WORKS.

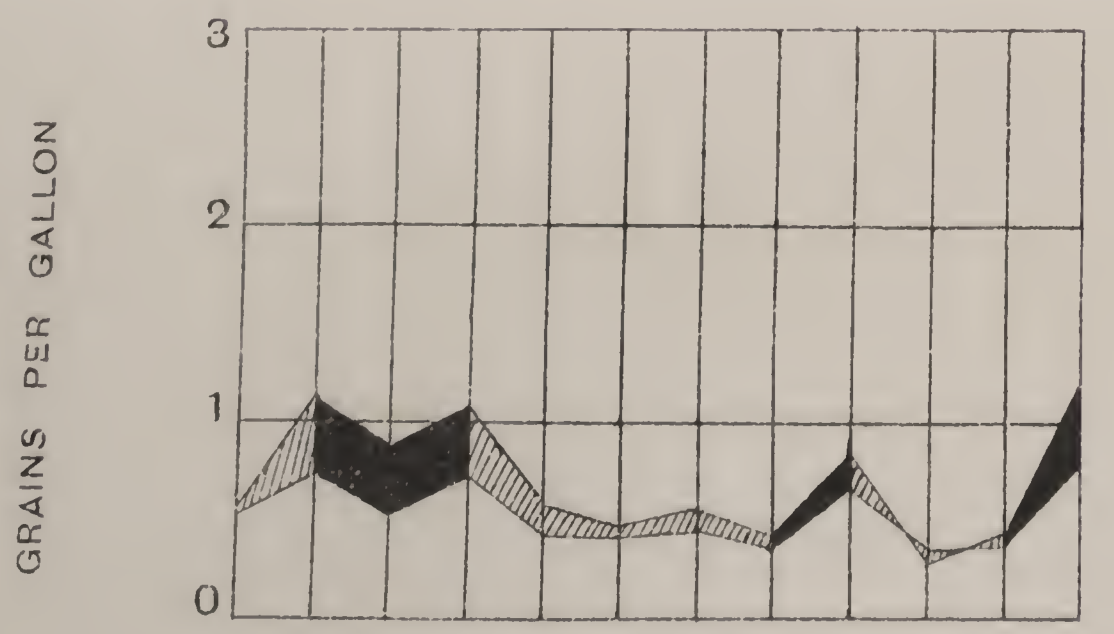
INCUBATOR TEST. **3 MINUTES OXYGEN ABSORPTION.**



ABOVE WORKS OUTFALL



AVERAGE EFFLUENT



BELOW WORKS OUTFALL

AVERAGE PER CENT. INCREASE AFTER INCUBATION